Australian Academy of Science

# AUSTRALIAN SCIENCE
# AUSTRALIA'S FUTURE

## SCIENCE 2035
### WHERE DO WE WANT TO BE?

## Acknowledgement of Country

The Australian Academy of Science acknowledges and pays respects to the Traditional Owners of all the lands on which the Academy operates, and where its Fellows and employees live and work. The Academy recognises Australia's Aboriginal and Torres Strait Islander peoples and honours their enduring connection to Country, from which we are committed to learn. We pay our respects to, and recognise the cultural authority of, their Elders past and present.

Academy RAP Innovate plan cover artwork, created by Richard Allan, Director, Traditional Core.

# AUSTRALIAN SCIENCE, AUSTRALIA'S FUTURE: **SCIENCE 2035**

## Acknowledgements

This project was guided by an advisory panel, chaired by Emeritus Professor Ian Chubb AC FAA FTSE. Thanks to advisory panel members for their time and expertise.

- Professor Andrew Cuthbertson AO FAA FTSE FAHMS
- Ms Mibu Fischer
- Professor Joan Leach
- Dr Martin Parkinson AC
- Professor Philip Poronnik
- Ms Kate Pounder
- Professor Margaret Sheil AO FAA FTSE
- Dr Ed Simpson
- Mrs Fiona Simson FTSE
- Dr Katherine Woodthorpe AO FTSE

Project management, analysis and drafting of this report was completed by the staff of the Australian Academy of Science, led by Dr Hayley Teasdale. Contributing staff members Lauren Sullivan, Alexandra Lucchetti, Dr Jasmine Schipp, Lauren Pay, Alexandra Williams, Dr Ben Swinton-Bland, Dr Rakshanya Sekar, Dr Maxine Newlands, Dr Negin Sarmadi, Negin Damabi, Dr Stuart Barrow, Chris Anderson, Kate Nairn, Lynn Allan, Allison Hornery, Wendy Wakwella, Melissa Abberton and Anna-Maria Arabia are gratefully acknowledged.

Through all stages of this project, many people volunteered their time and expertise with us. Without these people, our analysis would not have been possible. All the survey respondents, workshop participants, interviewees, and yarn participants are gratefully acknowledged.

This initiative was made possible through untied funding from the Michael Dopita FAA bequest. The Academy gratefully acknowledges Professor Michael Dopita AM FAA, whose gift was made 'in the sure knowledge that the money will be well spent in securing a more healthy, literate, rational and science-driven future for all Australians'.



Cite as: *Australian Academy of Science (2025). Australian science, Australia's future: Science 2035.*

DOI
10.82202/fph6-zg12

ISBN
Digital PDF: 978-0-85847-890-9
Printed Book: 978-0-85847-893-0

*The **challenges we face** as Australians have been well documented, as has our remarkably casual and piecemeal approach to addressing them — bit here, bit there, **but too little anywhere.***

# FOREWORD

## Opening speech delivered at the National symposium, *Australian science, Australia's future: Science 2035* (4 September 2025).

The *2025 Edelman trust barometer* reported that fewer than one in five (17%) of surveyed Australians thought that the next generation will be better off.[1]

This may be shocking to some of us; it should be to all of us.

The challenges we face as Australians have been well documented, as has our remarkably casual and piecemeal approach to addressing them – bit here, bit there, but too little anywhere.

And even when we try, too often we pull away when change becomes discomforting for some of us.

As Peter Hartcher wrote in *The Sydney Morning Herald* in June 2025: 'Can we, as a people, make big reforms to make our country better, even if it's hard? Or are we too selfish, too myopic, too complacent?'[2]

If we are not to let the pessimism (or selfishness) of most of us become a destabilising and destructive force, if we are to make big reforms, it is up to organisations like this Academy to stand up and show leadership.

We can, and we will. Because we want an Australian future influenced by strategy and careful choices; an approach that will inspire confidence that we have the wit and the will to build a better future.

It is not something only for this Academy, obviously. We are but one of many that needs to walk the walk.

Organisations and individuals with ambitions of leadership have to join the journey – deliver their share of the obligation to shape a future characterised by strategy and careful choices, not by complacency and drift.

The challenges we Australians face are clear. The *Intergenerational report 2023* plainly identifies the key challenges:

> **Five major forces that will shape the Australian economy over the coming decades are population ageing, expanded use of digital and data technology, climate change and the net zero transformation, rising demand for care and support services, and increased geopolitical risk and fragmentation. Australia's future prosperity will be influenced by how well we manage and maximise these shifts underway in the economy.[3]**

The Treasurer, in a speech on 18 June 2025, expressed his view that we have, 'an obligation to future generations to deliver a better standard of living than we enjoy today'[4].

An Australia capable of meeting that obligation needs to identify what to do, work out how to do it. And then, above all, to do what it must.

That Australian capability needs knowledge.

This Academy is in the business of knowledge. Australia as a nation needs to be in the knowledge business – there is not much you can do without it.

The Association of American University Professors spelt it out in 2019.

Without knowledge, they wrote:

> **...no nation can govern its economy, manage its environment, sustain its public health, produce goods or services, understand its own history, or enable its citizens to understand the circumstances in which they live.**

As Carl Sagan wrote, 'Our passion for learning is our tool for survival.'[5]

We know that without research, we won't learn anything. We will not add to the bank of knowledge that draws on the past while creating the basis for the future. Without respecting, refreshing, regenerating and creating knowledge, we will have no new capacity to design and respond to circumstances as they evolve.

We know that Australian research serves the nation. It contributes to the 'bank'; its quality earns us a seat at the global table where big and impactful decisions are made; it builds capability to evaluate, adapt and adopt knowledge – including from the roughly 97% produced elsewhere. It develops a culture in which curiosity – described as a hallmark of our species – is a value celebrated by a robust contemporary Australia.

We also know that without science, no nation can grow the knowledge it needs to solve the particular problems it must – or those it chooses to. It could not build an economy to support its aspirations. It is science that provides the knowledge to develop new products and technology that provides the know-how to make them; it is knowledge that results in new services, new products and new innovations that change the world.

But we also know that to make this country (and the world) better, the benefits of science will only be exploited through a renewed compact between science and society, based on a proper understanding of what science is trying to achieve.[6] Accordingly, science will work with other disciplines to understand the communities and the circumstances in which they live to ensure that the compact is fit for purpose.

It is surely time for Australia to make real commitment to invest in a future for all Australians; one we want rather than one largely determined by the decisions and inclinations of other governments.

Thirty-five years ago we might have thought we had.

Prime Minister Hawke announced in 1990 that he wanted Australia to be 'the clever country – one that must reduce its reliance on imported technology and borrowed research'.[7]

In that same year, John Dawkins, one of Hawke's Ministers, elaborated the theme:

> **More than ever before, the reservoir of talent in our people will have to eclipse our great natural resources as the determinant of our success. We will have to use our intelligence and our wit to cement the processes of change and to secure and improve our place in the world. This involves working better and smarter, scuttling mediocrity for quality and distinction. We cannot enter the next century rollicking on the sheep's back or creaking and swaying in some coal truck.[8]**

Twenty-six years after Hawke, Prime Minister Turnbull wanted Australia to become the 'innovation nation'.[9]

Thirty-five years after Hawke, the Federal Treasurer spelt out this government's ambition for reform and noted that 'our economy is not dynamic or innovative enough'.[4]

Notwithstanding the rhetoric, the exhortations and aspirations, we have barely moved the dial over the 35 years.

Indeed, do we still try? Since 2008, our investment in knowledge generation and its use – an outlay that is well understood to lead to dynamism and innovation – has dropped steadily. We are now so far behind the average of OECD countries as a percentage of GDP, for example, it would take around an additional $33.4 billion dollars per annum just to get to parity.

There is a pattern. We walk the path, and then again and then once more: lament the present, tell ourselves to get better and sometimes even outline how, make commitments and then slip back to the comfortable life that most of us lead even though we know it remains overly dependent on what we have been fortunate to find rather than work to earn – and just 17% of us presently riding the wave think the next generation will be as lucky.

Surely it is time to change. And it is our time.

This report is an investigation by the Australian Academy of Science into Australia's scientific capability needs by 2035. It is a decadal plan that has been developed using available data and based on multiple consultations.

The results are clear – we have gaps, and they need to be filled, or the challenges of 2060 will not be met, nor those of the National Reconstruction Fund.

We must act now: it takes time to develop the reservoir of talent in our people. It takes time to create knowledge, and it takes time to use that talent to apply that knowledge.

You will see examples of that timeframe attached to our report. But for the moment just think of things we take for granted and how basic knowledge from research led us to the quality of life many of us enjoy today.

In 1996, it was corporate leaders in the US who banded together to ask their Congress to:

> **Imagine what life would be like without polio vaccines and heart pacemakers. Or digital computers. Or municipal water purification systems. Or space-based weather forecasting. Or advanced cancer therapies. Or jet airliners. Or disease-resistant grains and vegetables. Or cardiopulmonary resuscitation.[10]**

The intervening 30 years have added a lot more to our world: wi-fi, smartphones, even more advanced cancer therapies, better vaccines, drought-tolerant agriculture, development of lasers for uses in industry and health care, quantum computers, computer-designed biologicals and therapies, to name a few.

And we know that:

> **Since 1945, 75% of all global economic growth is derivative of technological advance. And since 1990, 90% of that technical advance is derivative of fundamental scientific understanding... What history tells us is that without scientific and technological advance, we will be battered by calamity.[6]**

Real progress needs science, it needs time – so it needs patience.

In their letter, the corporate leaders describe how it is the 'truly "patient" capital needed to carry out basic research that creates the environment for the inspired risk-taking that is essential to technological discovery.' They describe how, 'often these advances have no immediate practical usability but open "technology windows" that can be pursued until viable applications emerge.'

Their letter describes a culture that understands the importance of knowledge and its critical role in the way we improve our lives.

This is our chance, indeed our obligation. The next generation will not be better off, if those who could change the outcome have neither the will to cope with the inconvenience nor the courage to stare it down.

We must recognise that there is no entitlement – nothing is our due simply because we are we.

Instead, let us be careful, selective, strategic and courageous – we can be better, but we have to make choices, work at them, and invest appropriately and carefully – this report points to some of what we need to do.

**Professor Chennupati Jagadish**
**AC PresAA FRS FREng FTSE**
Australian Academy of Science President


> ***The results are clear*** *— we have gaps, and they need to be filled, or the challenges of* ***2060*** *will not be met, nor those of the National Reconstruction Fund.*

# EXECUTIVE SUMMARY

## The prosperity and security of Australians depends on science.

Sovereign science is essential to develop the products and services that underpin national resilience, economic competitiveness, national security and social wellbeing.

Without science capability Australia will not effectively control its own destiny in a rapidly changing world.

Building sovereign science capability requires immediate action for long-term prosperity. If gaps are not addressed by 2035, Australia will not meet the challenges of 2060.

This report is a comprehensive, evidence-based effort to assess Australia's science capability against future needs.

At the core are the fundamental sciences: physics, chemistry, mathematics and biological sciences. The report describes the health of these disciplines.

For decades we have argued to grow investment in Australia's ability to deliver science in the national interest, but there has not been a convincing answer to questions about where those investments would best be directed. Where do we have strengths? Gaps? How does our science workforce capability connect with the ambitions of our country?

This report provides the answers to these questions, and provides a novel method to repeat this analysis for other sectors.

For the first time, we have the evidence needed to make informed decisions about how we can build science capability in Australia.

This report provides the answers to questions, about where and why, based on where we have strengths, gaps and the connection between science capability and the ambitions of our country. We must face up to the challenges we need to resolve if coming generations will enjoy an Australia at least as good as the one most of us enjoy today.

There is a misalignment of skills with the current and future needs of Australia.

As shortages in skills become evident, enrolments and graduations in relevant fields don't show signs of adaptability or responsiveness. That is partly due to the skills profile of the workforce being heavily dependent on the study choices of students from year 10 and beyond.

A system cannot adapt to what it cannot see. In some disciplines, including artificial intelligence (AI) and biotechnology, current gaps in data and classifications revealed in the analysis make it difficult to track our science capability, and to anticipate when it will, or won't, meet national demand.

This report is the beginning of a bigger discussion. Here we present the evidence that forms the basis for future analysis and potential solutions to the gaps identified.

Australia has tried to shift the dial on skills, innovation and productivity many times. This time, we have the evidence to guide what we need to do to get to where we want to be.

**It's time to change, this time.**

*There is a **misalignment** of skills with the current and future needs of Australia.*

# INTRODUCTION

*Australian science, Australia's future* is a comprehensive review of national science capability undertaken by the Australian Academy of Science. This analysis seeks to answer a fundamental question:

**Does Australia have the science capability and the capacity that it needs to meet the challenges faced by the coming generations?**

The Academy's position is straightforward: the Academy believes that today's Australians owe future generations a quality of life with security, and social and economic prosperity and cohesion that is the envy of the world.

It can be achieved, and will be, with careful identification and implementation of what needs to be done. Efforts must start now to build the capacity required to face the future with confidence and to harvest the benefits from the opportunities it provides.

## The reservoir of talent

Australia needs to build that reservoir of talent in our people. We will do so with an education and training system that is fit for a contemporary purpose. The expertise of individuals participating in modern Australian education will be complemented by sustained capability within the system – teachers supported with professional development, trainers with up-to-date materials and knowledge, academics with research support that builds the capacity and expertise, the reservoir of talent, to be drawn on as required by innovators and implementers who seek to change the economy. And specifically augmented opportunities for re-skilling as the aspirations and needs of individuals and the workforce change.

## The Intergenerational report

A search for gaps in capability without a clear target would be like taking a seat on the first passing bus because it's a bus, not knowing where it's going until you arrive.

For this analysis we needed to work down from an aspiration and up to a target.

The analysis uses the *Intergenerational report 2023: Australia's future to 2063* as a guide to what we must plan for: challenges that can be met with sovereign capability in the sciences. It embraces the National Reconstruction Fund priorities as achievements that must be met to influence the forces shaping the economy listed in the *Intergenerational report*.

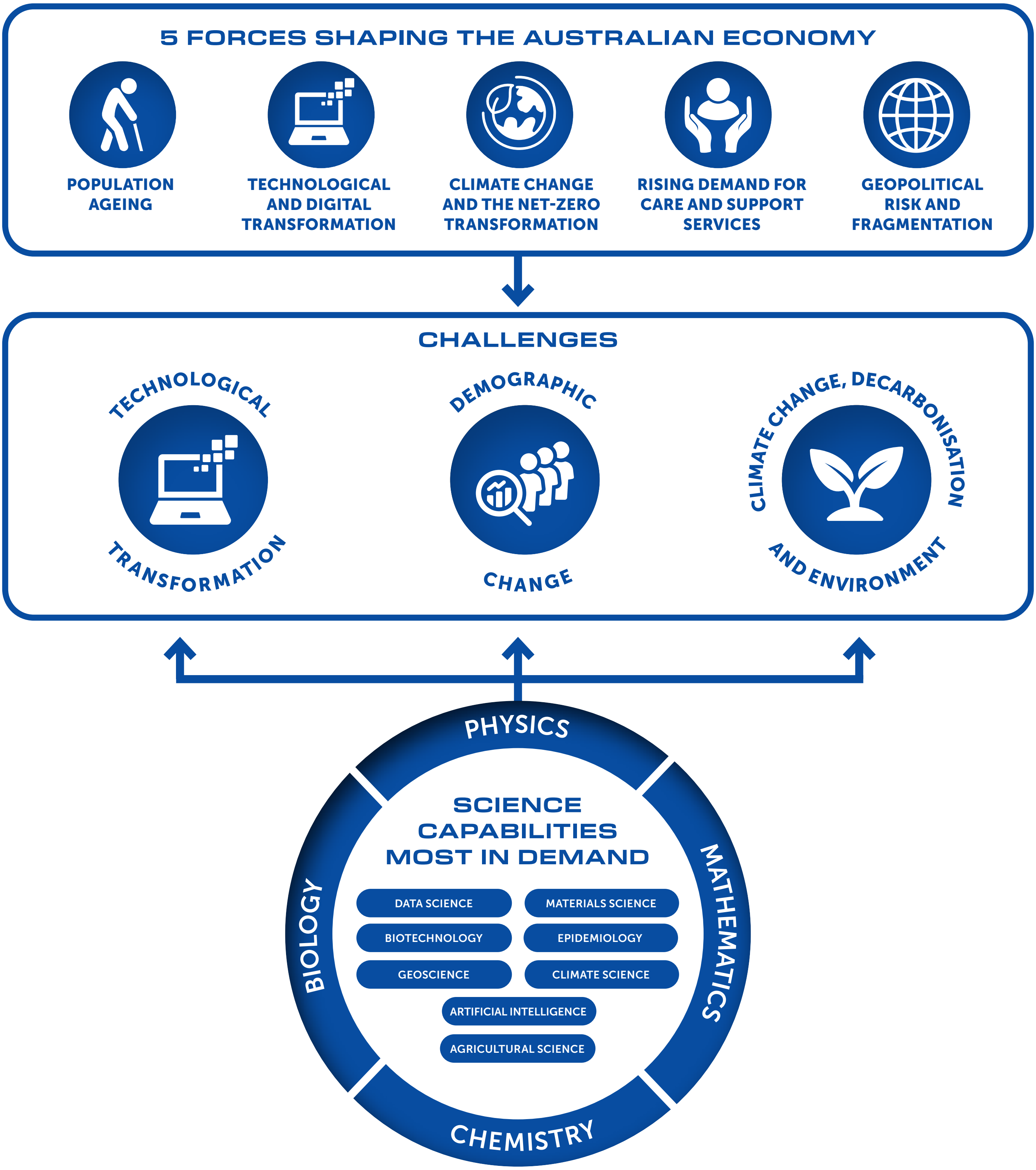
This is a study based on where our priorities and aspirations aim to take the nation – and asks whether we have the scientific capability and capacity to get us close to the goal.

The Academy takes the view that Australia needs to get the basics right by 2035 if we are to meet the obligation of intergenerational equity.

It will take close to 10 years to get the policies, processes and incentives in the right place and functioning well. Growing the skill sets to fill the gaps means not only persuading school students to choose the right subjects in their final years, then in university or TAFE, and postgraduate if relevant. It means thinking about the subjects students are offered, and whether they are fit for purpose and the teachers supported to teach them well. It means offering re-skilling opportunities as workforce requirements change. It means finding pathways for overseas students and skilled migrants to be part of filling the occupation shortages we have in critical areas. It means investment, and outcomes, not just costs.

Time, patience and careful development of policies will get us there. Muddling along mixed with hope and exhortation will not.

Drawing on data dashboards, expert workshops, and foresight techniques, the Academy mapped scientific capability and shortfalls across three major challenge areas: technological transformation; demographic change; and climate change, decarbonisation and environment. Analysis was underpinned by two context-shaping factors: national resilience and science literacy.




The project has identified eight critical science capability areas in Australia where demand is set to surge. The analysis has also identified weaknesses, strengths and relationships underpinning the supply and demand of each of these science capability areas.

The Academy's analysis – supported by data and informed by foresight – has shown where Australia's science capability is insufficient to meet our 2035 challenges.

It asks deep questions. For example, undergraduate student enrolments, and hence the teaching and research workforce, are not necessarily consistent with our ambitions and goals. How do we connect our national aspirations with who we are training?

If we have not built systems over the next 10 years that allow us to generate sustained momentum in the areas that matter to Australia, it will be too late.

If we have these systems in place by 2035, we can build the capacity Australia needs to provide its people with an enviable quality of life while contributing as a responsible global citizen.

# METHOD

**They key challenges were selected after a literature review of federal and state government reports. They were chosen based on how scientific capability aligns with the economic forces outlined in the Intergenerational report. The key challenges areas are:**


Following this, the Academy used survey results to map the key areas of science capability that sit under each challenge area. This survey informed the fields of research in scope for the data analysis, and the discipline experts that were shortlisted and selected to join the challenge workshop series. Further experts were invited from the Learned Academy Fellowships and the Academy's National Committees for Science.

The Academy compiled data dashboards to present information on the relevant science capability. Data included:

- *EDUCATION AND TRAINING*
- *WORKFORCE AND SKILLS*
- *ACTIVITIES AND OUTPUTS (PUBLICATIONS, PATENTS, COLLABORATIONS)*
- *EXPENDITURE AND FUNDING*
- *CHALLENGE-SPECIFIC DATA (E.G. EXPORT/IMPORTS, DEMOGRAPHIC TRENDS)*

The Academy conducted a series of workshops with Fellows from the Learned Academies, National Committee members and other leading experts to explore the future of the scientific scientific disciplines. Data dashboards were used to examine gaps in capability looking forward to 2035.

Following this, the Academy interviewed a range of demand-side stakeholders who are users of science or peak bodies for industry. The analysis of these interviews was used to confirm the key areas of capability growing in demand.

In collaboration with Monash Business School, forecasting was conducted to identify shifts in the science workforce in Australia; to help anticipate future demand for science capabilities; and to highlight potential workforce gaps as ageing and retirement reshape the workforce. A potential limitation of this analysis is that it includes both domestic and international student data. Over recent years, domestic enrolments have dropped while international enrolments have been rising; this shift may mask the full reality of future workforce gaps. This will be explored in more detail in future publications.

Data is presented on each of the areas of science capability growing most in demand throughout the report. For each data point on capability, a threshold was chosen for when it would be marked as 'increasing', 'decreasing' or 'remained similar'. These thresholds were selected with consideration of relative shifts over the coming decade, for example predicted size of workforce growth. These thresholds are detailed in Appendix B.

Academy Fellows engaged with Indigenous scientists in a series of yarns to gather a range of Aboriginal and Torres Strait Islander perspectives on the future of science. The format was informal and was an exchange of ideas and thoughts. With consent, these ideas have helped to inform and shape this report. The full method can be found at Appendix A.

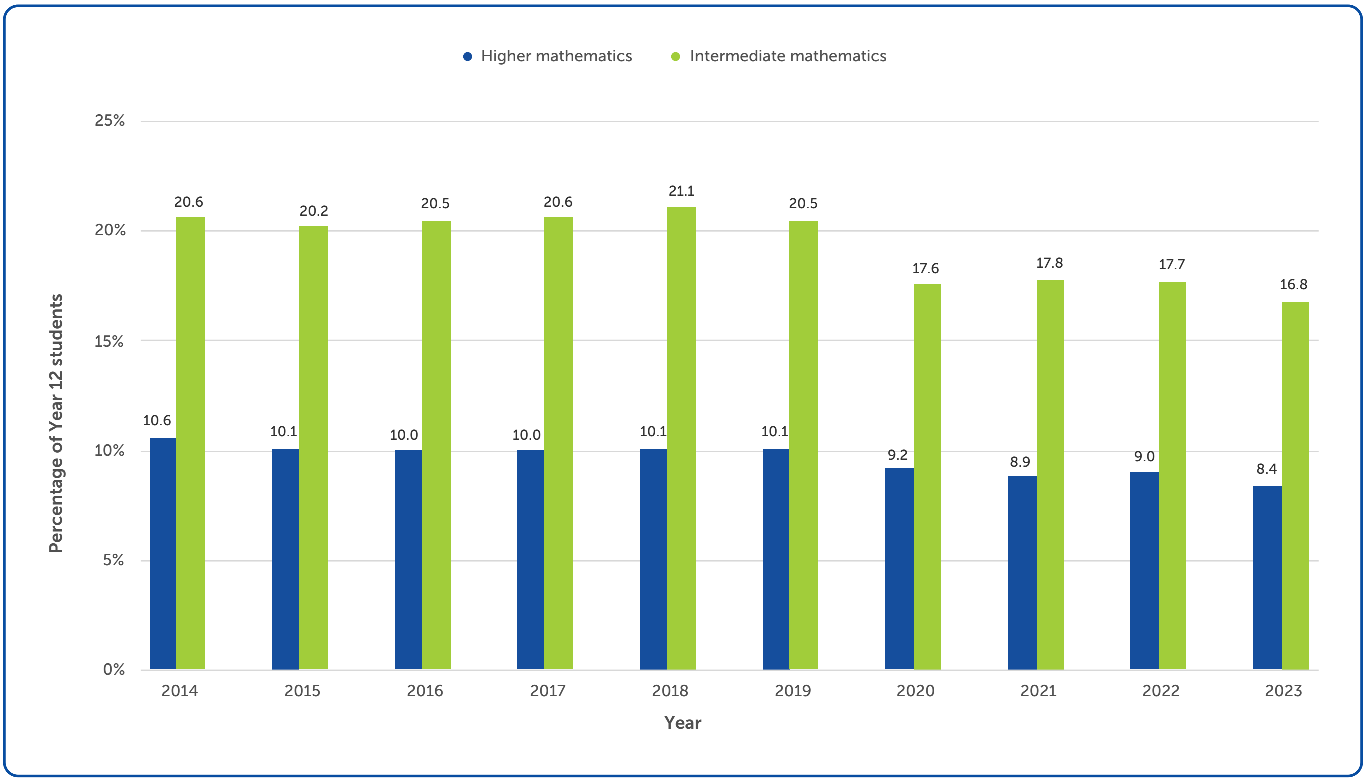
*Forecasting was conducted to identify shifts in the science workforce in Australia; to help **anticipate future demand** for science capabilities; and to highlight potential workforce gaps as ageing and retirement reshape the workforce.*

# TRENDS IN **AUSTRALIAN SCIENCE**

## Science education and training

- School performance in mathematics has declined since 2006 as recorded by PISA score.[11]
- In 2023 only 25.2% of students with a Year 12 qualification studied mathematics to at least intermediate level, compared to 30.6% in 2019 and 34.9% in 2008.[12,13]
- Teacher shortages have led to out-of-field teaching, with over a third of mathematics teachers and almost a quarter of science teachers teaching out of field in 2023.[14]

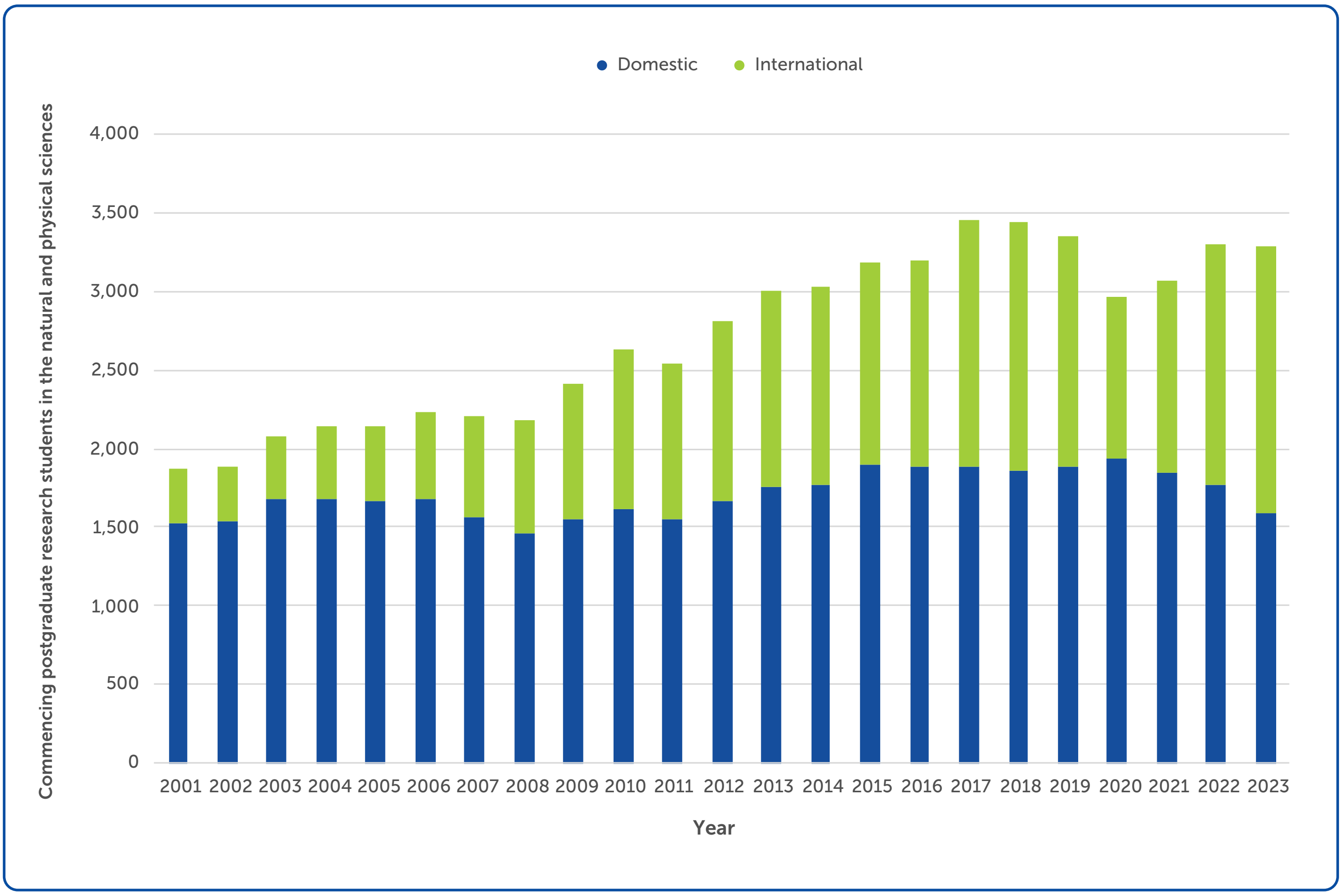
**Figure 1** – The percentage of Year 12 students in Australia studying higher and intermediate mathematics.
Source: Australian Mathematical Sciences Institute.



## Higher education

- From 2019 to 2023, the number of Vocational education and training (VET) enrolments in natural and physical science programs increased by 38% from 14,500 to 20,050.[15]
- Domestic undergraduate commencements in the natural and physical sciences have not returned to pre-COVID levels (36,296 in 2019 to 32,363 in 2023).[16]
- From 2020 to 2023, domestic postgraduate enrolments in natural and physical sciences fell 17%. At the same time, international postgraduate enrolments rebounded from the pandemic and surpassed domestic enrolments. In 2023, there were around 2,000 more international than domestic postgraduate enrolments in natural and physical sciences.[16]
- In Australia, Higher Degree by Research (HDR) students comprise more than half the research workforce (57% in 2020).[17] Domestic enrolments are falling.
- The full-time base stipend for a PhD student in Australia is $33,511 (tax free).[18] The minimum wage in Australia is $49,296 (subject to income tax).[19]
- Among international university students in Australia, 28% use their post-study work rights and 16% become permanent residents.[20]

**Figure 2** – Commencing domestic and international postgraduate research student enrolments in natural and physical sciences. Source: Department of Education.

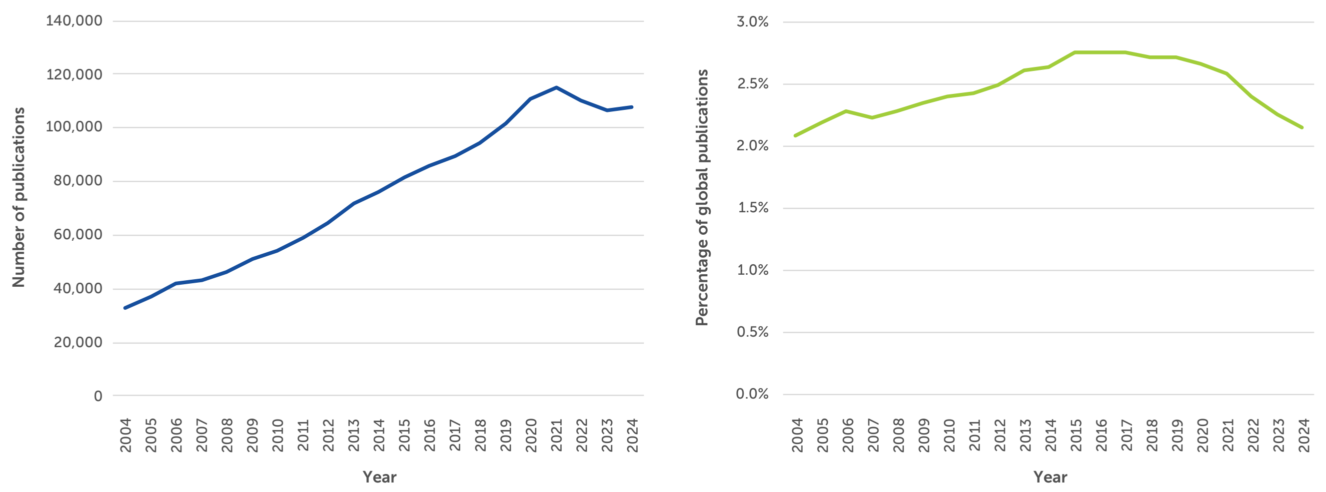


*Currently, Australian business R&D investment stands at just 0.89% of GDP, less than half the OECD average of 1.99%. In dollar terms, businesses invest $32.5 billion less than the OECD average.*

## Research outputs

- As of 2025, Australia produces 2.1% of the world's scientific publications despite having only 0.3% of the global population, ranking sixth among OECD nations for publications per capita/per million people.
- Of the most highly cited researchers, 4.5% are based in Australia.[21]
- Australia's number of research publications are increasing across many areas of science, with some exceptions such as geoscience and mathematics. However Australian publications are broadly falling as a proportion of global publications, due to other countries publishing more than ever before.

**Figure 3** – Australia's publications in science* compared with Australia's publications in science as a proportion of global publications. Source: Dimensions AI.




**Includes the following fields of research (FoR) codes: 30 Agricultural, veterinary and food sciences; 31 Biological sciences; 32 Biomedical and clinical sciences; 34 Chemical sciences; 37 Earth sciences; 40 Engineering; 41 Environmental sciences; 42 Health sciences; 46 Information and computing sciences; 49 Mathematical sciences; 51 Physical sciences; and 52 Psychology.*

## Research investment and infrastructure

- Federal R&D investment is spread across 151 programs and 13 portfolios.[22]
- Australia's R&D expenditure as a percentage of GDP has declined over the past 15 years to 1.68%.[23]
- Currently, Australian business R&D investment stands at just 0.89% of GDP, less than half the OECD average of 1.99%. In dollar terms, businesses invest $32.5 billion less than the OECD average.[23]
- Australian government investment in R&D is at a historic low. In dollar terms, the government underinvests in R&D by $1.8 billion per annum compared to the OECD average.[23]
- Critical gaps exist in national research infrastructure, notably next-generation high-performance computing and data, satellite capability, and coordinated climate science.[24]

## Diversity in STEM

- Aboriginal and Torres Strait Islander peoples remain underrepresented in science, technology, engineering and mathematics (STEM), with less than 1% holding a university STEM qualification in 2016, compared to 5% of the non-Indigenous adult population.[25]
- Women remain underrepresented in STEM holding only 15% of STEM-qualified roles in 2023, earning less, and holding fewer leadership roles.[26]

# AUSTRALIA'S CAPABILITY TO **MEET NATIONAL CHALLENGES**

**This initiative analysed Australia's science capability to meet three national challenges, informed by the forces shaping the economy listed in the *Intergenerational report*.**

The challenges are defined as follows:

**Demographic change:** Australia is ageing, with 17% of the population over 65 years of age, while the total fertility rate is down from 3.5 in the 1960s to 1.6 in 2022. Growth in urban and regional cities and an increasingly diverse population poses unprecedented demands on health care, education, and food supply.

**Technological transformation:** Rapid technological change is occurring in most areas of life and living, from cars and cooking to communication, health and security. Rapid digitalisation and advances in AI are predicted to create 150,000 jobs by the next decade. Australia's sovereign capabilities must be built and sustained and ensure the responsible adoption of emerging technologies.

**Climate change, decarbonisation and environment:** Transitioning to a net-zero economy, and building national resilience against climate impacts, are imperative.

In the analysis, we describe two underpinning enablers that establish how science capability is built and delivered. Whatever Australia chooses to do, and however the challenges change over the coming decade, there are two enduring enablers:

**Science literacy and education:** Australians need both education and training. Education develops a capacity to learn and builds an ability to adjust to circumstances as they change. Training provides a particular skill set for a particular purpose. The outcome must be informed citizens who understand how science works and are more resilient to misinformation and disinformation.

**Geopolitical tensions and national resilience:** In an increasingly uncertain international environment, a lack of economic diversity and limited onshore capabilities leave Australia vulnerable to external shocks.

# KEY AREAS OF SCIENCE WITHIN EACH CHALLENGE

**The workshops, interviews and data identified the key areas of science growing in demand within each of the challenge areas. These are outlined below.**

## Science and demographic change

**Modelling, statistics, demography,** and **data science** to monitor and understand Australia's changing population.

**Health expertise** with an increasingly ageing population and increasing burden of chronic conditions. To prevent, treat and manage chronic conditions we need **preventative healthcare experts.**

**Personalised medicine** draws upon fields including genomics and computer science.

**Climate science** and **climate adaptation science** can anticipate and mitigate the impact of climate change on human health, agriculture, and the built environment.

**Public health and epidemiology** will be needed for treatment of chronic diseases, particularly in an ageing population.

## Science and technological transformation

**Biotechnology** including for sustainable foods, crop protection, and personalised health care – underpinned by expertise in bioinformatics, data science, modelling, computational biology, bioengineering, biochemistry, and material biophysics.

**Precision agriculture** including agricultural science, Earth system science, geoscience, Earth observation and materials science.

**Climate adaptation** underpinned by science including climate science, synthetic biology, RNA technology, plant science, molecular biology, automation, AI and machine learning, Indigenous science, biochemistry, biotechnology, and ecology.

**Cryptography, typography, and quantum cryptography** supported by mathematical and computational expertise to maintain Australia's cybersecurity.

**Data science expertise**, supported by mathematical and computational expertise.

## Science and climate change, decarbonisation and environment

Climate science drawing on fundamental science from **physics, biology, mathematics and chemistry**. For example, chemistry is required for an understanding of ocean pH, or how carbon is stored in soil.

**Atmospheric physics and chemistry, meteorology, geophysics, hydrology, biogeochemistry, and landscape ecology** to strengthen Australia's climate resilience and adaptation efforts. These disciplines provide insights into weather patterns, carbon cycles, ecosystem dynamics, and the physical processes driving environmental change.

**Oceanography** for understanding oceans as carbon sinks, and the impact of elevated temperature and decreasing pH on ocean currents and food chains.

**AI-powered climate models** simulating scenarios to provide insights for carbon reduction and adaptation strategies. Innovations like AI-equipped cube satellites to enhance **disaster response capabilities and environmental monitoring**.

**Agriculture and mathematics** to predict future climate and weather patterns and their effects on crop production, including supporting climate-smart agriculture technologies and decarbonised agricultural systems.

# THE FUNDAMENTAL SCIENCES **MATHEMATICS, BIOLOGY, CHEMISTRY AND PHYSICS**

**Australia's national science capability depends on a robust foundation in the fundamental sciences. Disciplines such as physics, chemistry, mathematics and biology are not only fields of discovery in their own right – they provide the conceptual and technical bedrock for advances across health, energy, environment, agriculture, defence, and emerging technologies.**

Without strength in these core areas, applied science loses its scaffold, and we lose the ability to respond to complex challenges.

Investing in fundamental science is not separate from building strategic capability, it is central to it.

Whether modelling climate systems, developing new materials, understanding biological processes or securing data infrastructure, progress relies on the deep expertise and tools that originate in the basic sciences.

## Data descriptions

Here we analyse Australia's current capability in the fundamental sciences, including trends in education, workforce, funding and research output. The sources used to inform this analysis are listed in Appendix B. Thresholds for the rating scale – delineating increase, decrease or remaining the same – are described in Appendix B.

The COVID-19 pandemic had an observable impact on the education enrolments and completions data used. Care should be taken interpreting these trends in this context.

Where relevant, patterns observed between the start and end year for an indicator are noted to provide additional context.

## Rating scale

- **No trends decreasing. No gap or unlikely to have a gap in capability.**
- **Some trends decreasing or no majority of increasing trends. Some gap or likely gap in capability.**
- **Most trends decreasing. Existing gap or certain gap in capability.**
- **Insufficient data available.**

# MATHEMATICS

## Education

- Year 12 students enrolled* in a mathematics (Australian Curriculum learning area) subject **remained similar** from 162,367 in 2013 to 156,253 in 2022 (-3.77%).
- The percentage of Year 12 students enrolled in a mathematics (Australian Curriculum learning area) subject **decreased** from 72.40% in 2013 to 67.90% in 2022 (-6.22%).
- Year 12 enrolments** in mathematical sciences (Australian Standard Classification of Education (ASCED), narrow field 0101) **remained similar** from 191,131 in 2013 to 187,777 in 2022 (-1.75%).
- Year 12 enrolments in intermediate mathematics **decreased** between 2013 and 2022 (-6.72%).
- Year 12 enrolments in higher mathematics **decreased** between 2013 and 2022 (-8.62%).

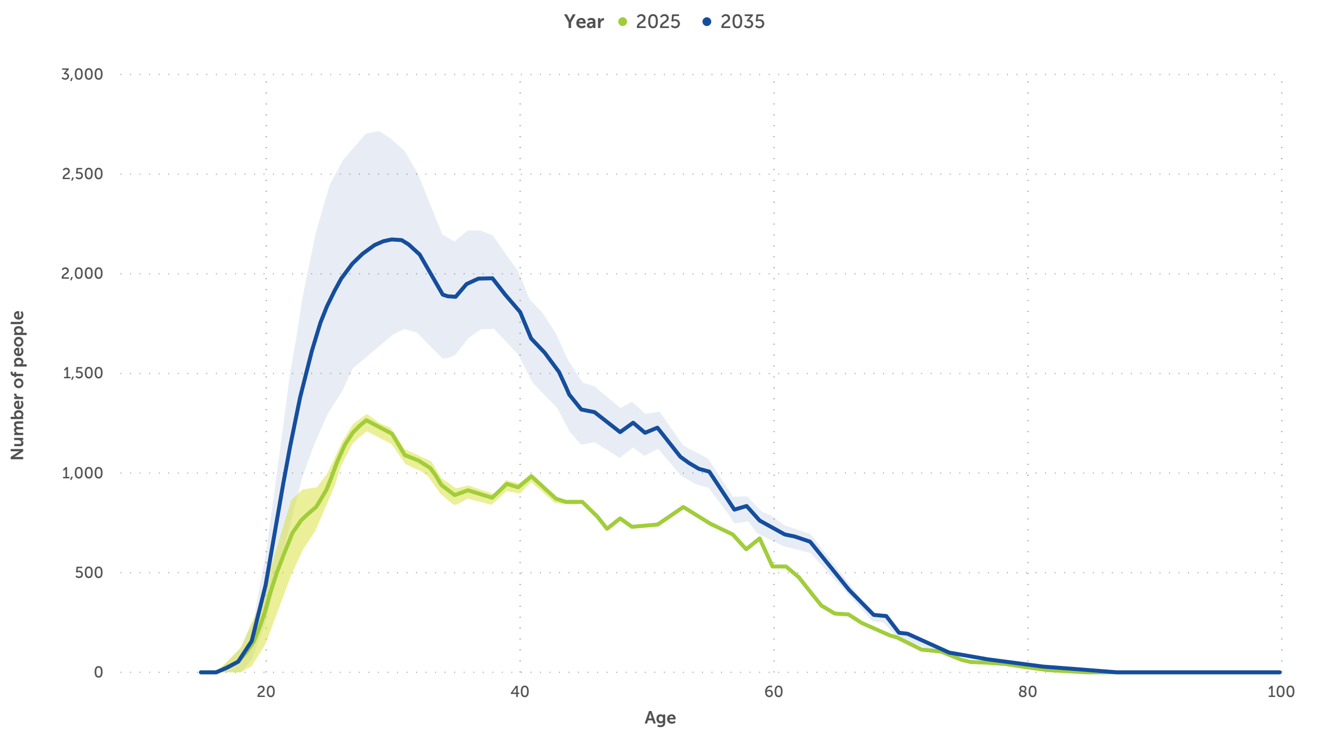
**This is a count of students. Students are only counted once even if they are enrolled in multiple mathematics subjects.*

***This is a count of enrolments. Students may be counted twice if they are enrolled in multiple mathematics sciences subjects.*

## Workforce

- Mathematical science professionals (Australian and New Zealand Standard Classification of Occupations (ANZSCO) 2022, unit group 2241) had **shortages** in New South Wales, Western Australia and the Northern Territory in 2024.
- Mathematical sciences (ASCED, narrow field 0101) is projected to have an **expansive workforce** over the next decade (10 years (2025–2035)).
- Actuaries, mathematicians and statisticians (ANZSCO 2013 version 1.3, unit group 2241)[2] employment is projected to **increase** from 11,100 to 14,600 (31.4%) between 2024 and 2034. This is **higher than** total projected employment growth (13.7%).

**Figure 4** – Forecasted age distribution of the working population with a university qualification in mathematical sciences in 2025 and 2035. Shaded areas represent 90% prediction intervals.




## Funding

- Expenditure on R&D in mathematical sciences (Australian and New Zealand Standard Research Classification (ANZSRC) 2020, division 49) by business **decreased** from $37 million* in 2012 to $32 million** in 2022 (-12.72%).
- Expenditure on R&D in mathematical sciences (ANZSRC 2020, division 49) by government **increased** from $53 million* in 2012 to $188 million in 2022 (254.59%).
- Expenditure on R&D in mathematical sciences (ANZSRC 2020, division 49) by higher education **decreased** from $211 million* in 2012 to $177 million in 2022 (-16.22%).
- Data are not available for private non-profit organisations.

**Normalised to June 2022 Consumer Price Index. Uses closest equivalent ANZSRC 2008 code.*

## Research output

- Australian publications in mathematical sciences (ANZSRC 2020, division 49) **decreased** from 2,383 in 2015 to 1,933 in 2024 (-18.88%).
- Australian patents in mathematical sciences (ANZSRC 2020, division 49) **decreased** from 391 in 2015 to 258 in 2024 (-34.02%).

EDUCATION WORKFORCE FUNDING RESEARCH OUTPUT

# PHYSICS

## Education

- Year 12 enrolments in physics and astronomy (ASCED, narrow field 0103) have **decreased** from 30,686 in 2013 to 25,984 in 2022 (-15.32%).

## Workforce

- Physicists (ANZSCO 2022, occupation 234914) had a **shortage** in Queensland in 2024.
- Physics and astronomy (ASCED, narrow field 0103) is projected to have an **ageing workforce** over the next decade (2025–2035).
- Employment of other natural and physical science professionals is projected to increase from 14,900 in 2024 to 18,200 in 2034 (21.8%). This is **higher than** total projected employment growth (13.7%).

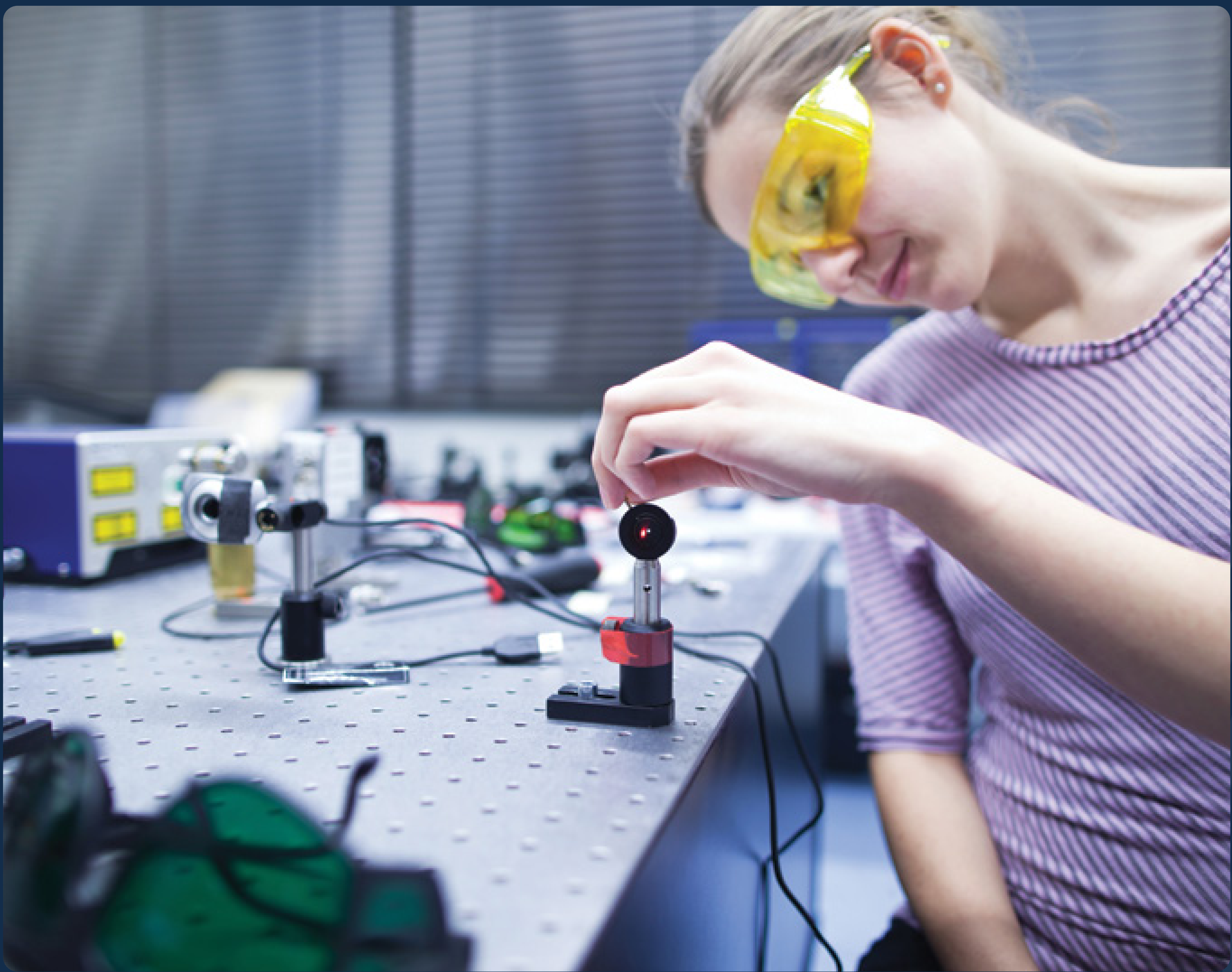
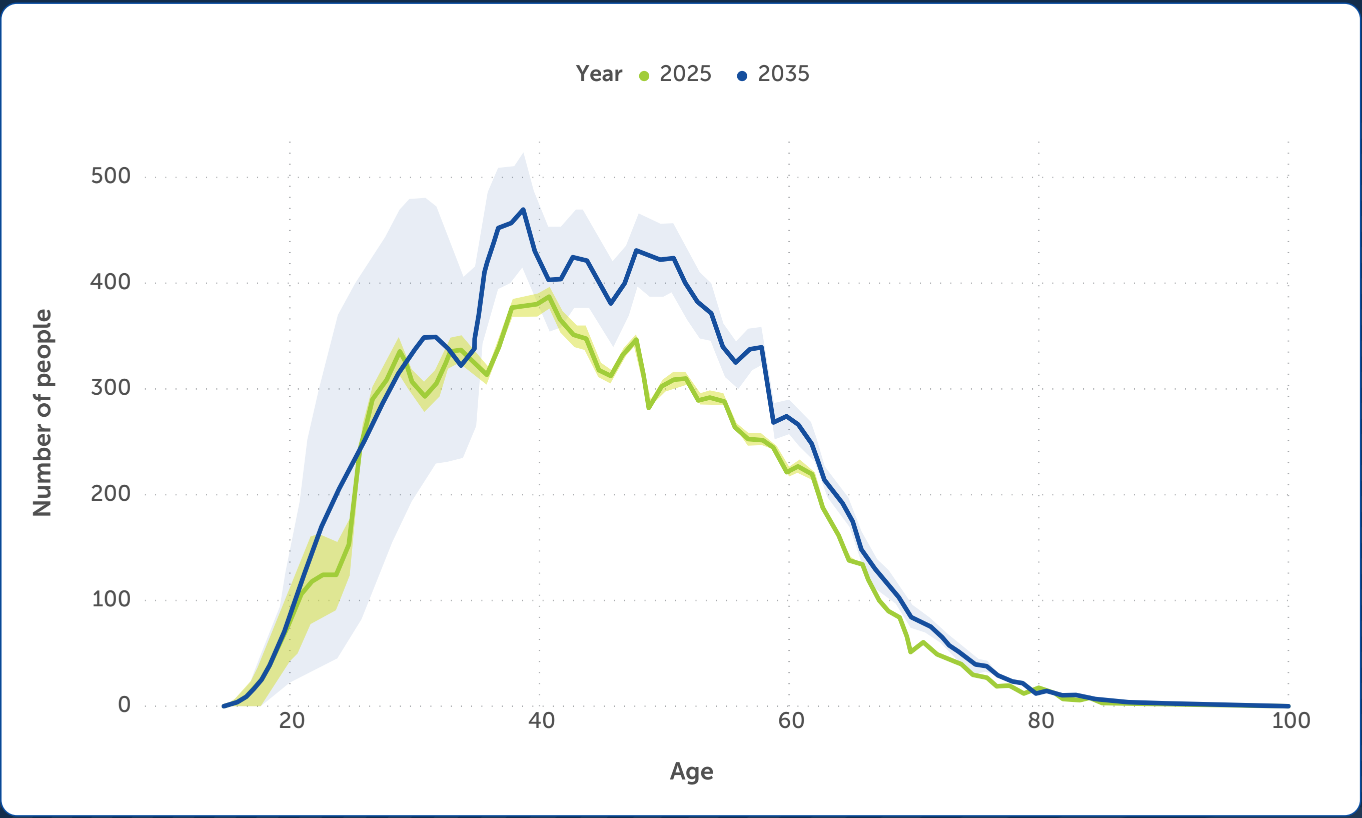


**Figure 5** – Forecasted age distribution of the working population with a university qualification in physics and astronomy in 2025 and 2035. Shaded areas represent 90% prediction intervals.




## Funding

- Expenditure on R&D in physical sciences (ANZSRC 2020, division 51) by business **increased** from $59 million* in 2012 to $138 million** in 2022 (136.50%).
- Expenditure on R&D in physical sciences (ANZSRC 2020, division 51) by government **increased** from $160 million* in 2012 to $282 million in 2022 (75.81%).
- Expenditure on R&D in physical sciences (ANZSRC 2020, division 51) by higher education **increased** from $392 million* in 2012 to $441 million in 2022 (12.59%).
- Data are not available for private non-profit organisations.

**Normalised to June 2022 Consumer Price Index. Uses closest equivalent ANZSRC 2008 code.*

## Research output

- Australian publications in physical sciences (ANZSRC 2020, division 51) **increased** from 4,471 in 2015 to 4,919 in 2024 (10.02%), peaking at 5,250 in 2020.
- Australian patents in physical sciences (ANZSRC 2020, division 51) **remained similar** from 940 in 2015 to 1,025 in 2024 (9.04%).

# BIOLOGY

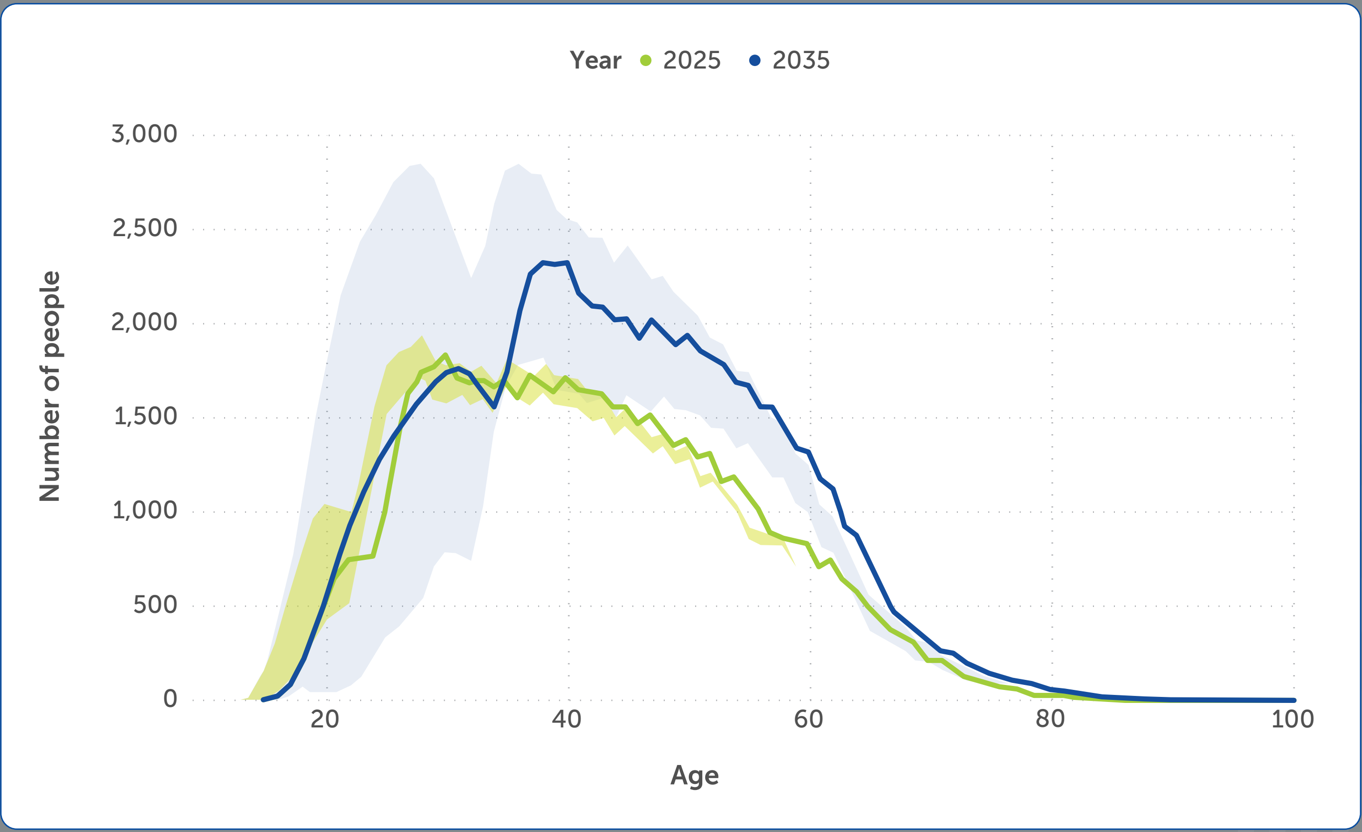
## Education

- Year 12 enrolments in biological sciences (ASCED, narrow field 0109) **increased** from 56,522 in 2013 to 61,491 in 2022 (8.79%).

## Workforce

- Life scientists (ANZSCO 2022, unit group 2345) had **no shortages** in 2024.
- Biological sciences (ASCED, narrow field 0109) is projected to have an **ageing workforce** over the next decade (2025–2035).
- Life scientists (ANZSCO 2013 version 1.3, unit group 2345) employment is projected to **increase** from 10,400 in 2024 to 12,200 in 2034 (17.8%). This is **similar to** total projected employment growth (13.7%).

**Figure 6** – Forecasted age distribution of the working population with a university qualification in biological sciences in 2025 and 2035. Shaded areas represent 90% prediction intervals.



## Funding

- Expenditure on R&D in biological sciences (ANZSRC 2020, division 31) by business **increased** from $142 million* in 2012 to $345 million in 2022 (143.49%).
- Expenditure on R&D in biological sciences (ANZSRC 2020, division 31) by government **decreased** from $533 million* in 2012 to $433 million in 2022 (-18.74%).
- Expenditure on R&D in biological sciences (ANZSRC 2020, division 31) by higher education **remained similar** from $1,056 million* in 2012 to $1,088 million in 2022 (3.03%).
- Expenditure on R&D in biological sciences (ANZSRC 2020, division 31) by private non-profit organisations **decreased** from $96 million* in 2012 to $17 million in 2022 (-82.47%).

**Normalised to June 2022 Consumer Price Index. Uses closest equivalent ANZSRC 2008 code.*

## Research output

- Australian publications in biological sciences (ANZSRC 2020, division 31) **increased** from 10,757 in 2015 to 12,085 in 2024 (-12.35%). Publications peaked at 14,945 in 2021 and **decreased** between 2021 and 2024 (-19.14%).
- Australian patents in biological sciences (ANZSRC 2020, division 31) **decreased** from 1,791 in 2015 to 1,568 in 2024 (-12.45%).

EDUCATION WORKFORCE FUNDING RESEARCH OUTPUT

# CHEMISTRY

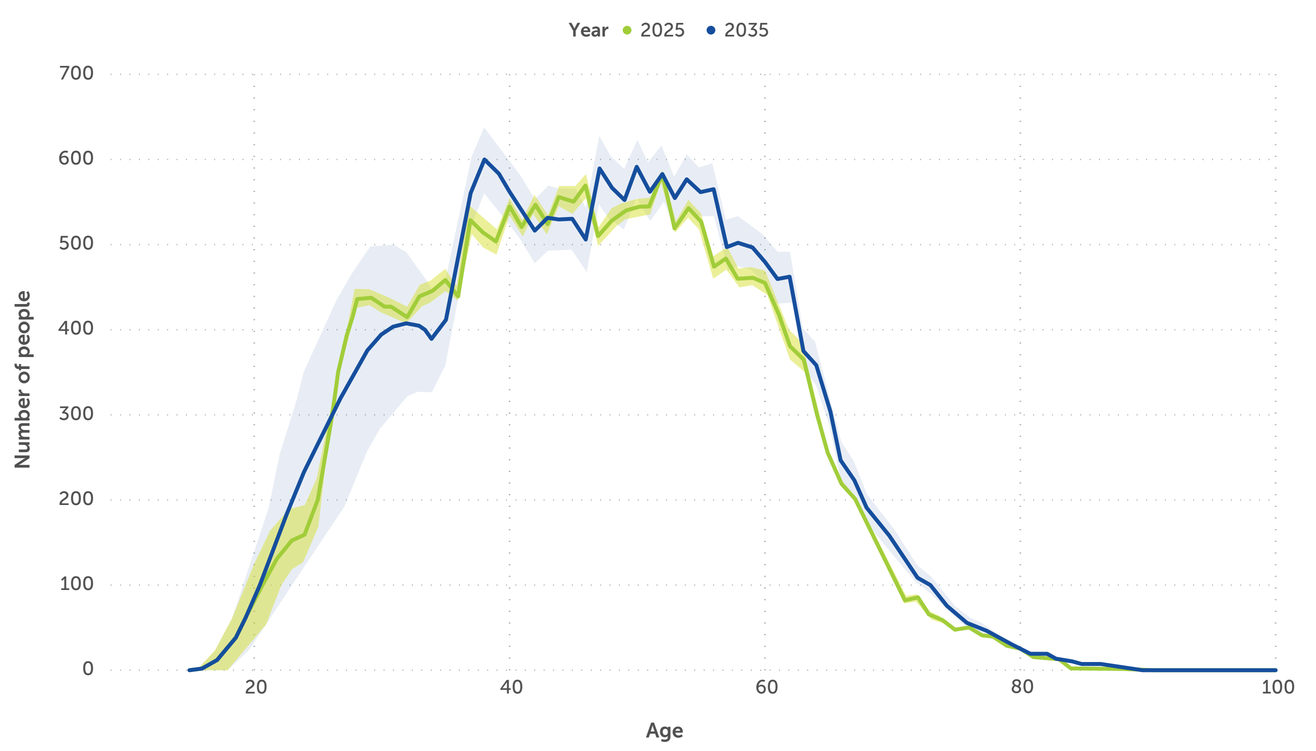
## Education

- Year 12 enrolments in chemical sciences (ASCED, narrow field 0105) decreased from 38,993 in 2013 to 36,516 in 2022 (-6.35%).

## Workforce

- Chemists (ANZSCO 2022, occupation 234211) had **no shortages** in 2024.
- Chemical sciences (ASCED, narrow field 0105) is projected to have a **stationary workforce** over the next decade (2025–2035).
- Chemists, and food and wine scientists (ANZSCO 2013 version 1.3, unit group 2342) employment is projected to **increase** from 10,300 in 2024 to 11,600 in 2034 (13.3%). This is **similar to** total projected employment growth (13.7%).

**Figure 7** – Forecasted age distribution of the working population with a university qualification in chemical sciences in 2025 and 2035. Shaded areas represent 90% prediction intervals.




## Funding

- Expenditure on R&D in chemical sciences (ANZSRC, division 34) by business **decreased** from $535 million* in 2012 to $393 million in 2022 (-26.54%).
- Expenditure on R&D in chemical sciences (ANZSRC, division 34) by government **decreased** from $204 million* in 2012 to $181 million in 2022 (-10.90%).
- Expenditure on R&D in chemical sciences (ANZSRC, division 34) by higher education **decreased** from $449 million* in 2012 to $352 million in 2022 (-21.67%).
- Data are not available for private non-profit organisations.

**Normalised to June 2022 Consumer Price Index. Uses closest equivalent ANZSRC 2008 code.*

## Research output

- Australian publications in chemical sciences (ANZSRC, division 34) **increased** from 5,003 in 2015 to 6,366 in 2024 (27.24%).
- Australian patents in chemical sciences (ANZSRC, division 34) **remained similar** from 1,713 in 2015 to 1,781 in 2024 (3.97%).

# SCIENCE CAPABILITIES INCREASING **MOST IN DEMAND TO 2035 ACROSS ALL CHALLENGE AREAS**

Based on all the data collated across the three challenge areas, the top eight science capability areas increasing in demand by 2035 are below:

- AGRICULTURAL SCIENCE
- ARTIFICIAL INTELLIGENCE
- BIOTECHNOLOGY
- CLIMATE SCIENCE
- DATA SCIENCE
- EPIDEMIOLOGY
- GEOSCIENCE
- MATERIALS SCIENCE

Credit: Mei Sun Yee / Monash University

# GAPS IN CAPABILITY **AT A GLANCE**

| | Agricultural science | Artificial intelligence | Biotechnology | Climate science | Data science | Epidemiology | Geoscience | Materials science |
|---|---|---|---|---|---|---|---|---|
| **Year 12 enrolments** | Sideways thumb | Thumbs down | Thumbs down | Sideways thumb | Thumbs down | Sideways thumb | Sideways thumb | Sideways thumb |
| **Vocational education and training (VET) completions** | Sideways thumb | Thumbs down | ? | ? | Thumbs down | Thumbs down | ? | Sideways thumb |
| **VET enrolments** | Sideways thumb | Sideways thumb | ? | Thumbs down | Sideways thumb | Sideways thumb | Thumbs down | Sideways thumb |
| **University graduates** | Sideways thumb | Thumbs up | Thumbs up | Thumbs up | Thumbs up | Thumbs up | Thumbs down | Sideways thumb |
| **Undergraduate completions** | Sideways thumb | Thumbs up | ? | Thumbs down | Thumbs up | Thumbs down | Thumbs down | Thumbs down |
| **Postgraduate completions** | Sideways thumb | Thumbs up | ? | Thumbs down | Thumbs up | Thumbs up | Sideways thumb | Sideways thumb |
| **Undergraduate enrolments (commencing)** | Sideways thumb | Sideways thumb | ? | Thumbs down | Sideways thumb | Sideways thumb | Sideways thumb | Thumbs down |
| **Postgraduate enrolments (commencing)** | Sideways thumb | Sideways thumb | ? | Sideways thumb | Sideways thumb | Thumbs up | Sideways thumb | Sideways thumb |
| **Current workforce** | Sideways thumb | ? | Sideways thumb | ? | Sideways thumb | ? | Thumbs down | Sideways thumb |
| **Projected workforce** | Thumbs up | ? | ? | Thumbs down | Thumbs up | ? | Thumbs down | Thumbs down |
| **R&D expenditure** | Sideways thumb | Thumbs up | ? | Sideways thumb | Sideways thumb | Thumbs up | Sideways thumb | Thumbs down |
| **Publications** | Thumbs up | Thumbs up | Thumbs up | Thumbs up | Sideways thumb | Thumbs up | Sideways thumb | Sideways thumb |
| **Patents** | Sideways thumb | Thumbs up | Thumbs up | Thumbs down | Thumbs up | Thumbs down | Sideways thumb | Sideways thumb |

# AGRICULTURAL SCIENCE

## Underpinning fundamental science disciplines

CHEMISTRY | BIOLOGY | MATHEMATICS | PHYSICS

## What is agricultural science?

Agricultural science is broadly defined as the science of food, feed, fibre and biofuel production, including plant-derived pharmaceuticals and industrial products.

*Note: this report focuses specifically on food production, which was the primary focus of the workshops.*

## Data classification codes in scope

| | |
|---|---|
| **Learning areas**<br>*Australian Curriculum* | SCIENCE |
| **Fields of education**<br>*Australian Standard Classification of Education (ASCED)* | **CLOSEST MATCH**<br>• 05 Agriculture, environmental and related studies<br>o 0501 Agriculture<br>» 050101 Agricultural science<br>» 050105 Animal husbandry<br>o 0503 Horticulture and viticulture<br>» 050301 Horticulture<br>» 050303 Viticulture<br>o 0599 Other agriculture, environmental and related studies<br>» 059901 Pest and weed control<br><br>**UNDERPINNING OR CLOSELY RELATED FIELDS**<br>• 01 Natural and physical sciences<br>» 0105 Chemical sciences<br>» 0109 Biological sciences |
| **Fields of research**<br>*Australian and New Zealand Standard Research Classification (ANZSRC) 2020* | • 30 Agricultural, veterinary and food sciences*<br>o 3001 Agricultural biotechnology<br>o 3002 Agriculture, land and farm management (includes management of soil for agricultural production)<br>o 3003 Animal production<br>o 3004 Crop and pasture production<br>o 3008 Horticultural production<br>*Note: Closest equivalent ANZSRC 2008 code used for R&D expenditure data (07 Agriculture and veterinary sciences) |
| **Occupations**<br>*Australian and New Zealand Standard Classification of Occupations (ANZSCO)* | ANZSCO 2022<br>• 2341 Agricultural, fisheries and forestry scientists<br>o 234114 Agricultural research scientist<br><br>ANZSCO 2013 V1.3<br>• 2341 Agricultural and forestry scientists<br>o 234112 Agricultural scientist |

## What is driving demand for agricultural science?

Australia is food secure, with approximately two thirds of fresh produce available for Australian consumers grown and processed in-country.

Approximately 70% of production is exported, largely to the region. Food and grocery exports totalled AUD$48 billion in 2022–23 while agriculture, fisheries and forestry exports totalled AUD$75.6 billion in 2023–24.[27,28]

Australia's food export sector has high growth potential, driven by strong and growing demand in our region. Unlocking this potential depends on innovation and resilience in the face of climate change and variables such global market challenges.

Environmental challenges are increasing in complexity and intensity. They include climate and weather changes, microplastics, and changing soil quality.

These challenges will continue to alter growing conditions in Australia, requiring flexibility and capacity to deploy new approaches.

While 99% of Australian farm businesses are Australian owned, much of the IP for crop development and new product development is owned by international multinationals.[29]

Australia imports fertilisers, agricultural chemicals, and animal pharmaceuticals.

Nitrogenous fertilisers contribute more than 60% of Australia's carbon footprint from crop production. They are a major cost for farmers.

## Will Australia have sufficient capability to meet demand in agricultural science?

Enrolments and completions in agriculture across Year 12, VET and undergraduate university levels have either held steady or grown, indicating a sustained interest in the field.

However, domestic postgraduate enrolments in agriculture have declined, while international enrolments at this level have increased. This is a trend worth watching as we consider long-term national capability in agricultural science.

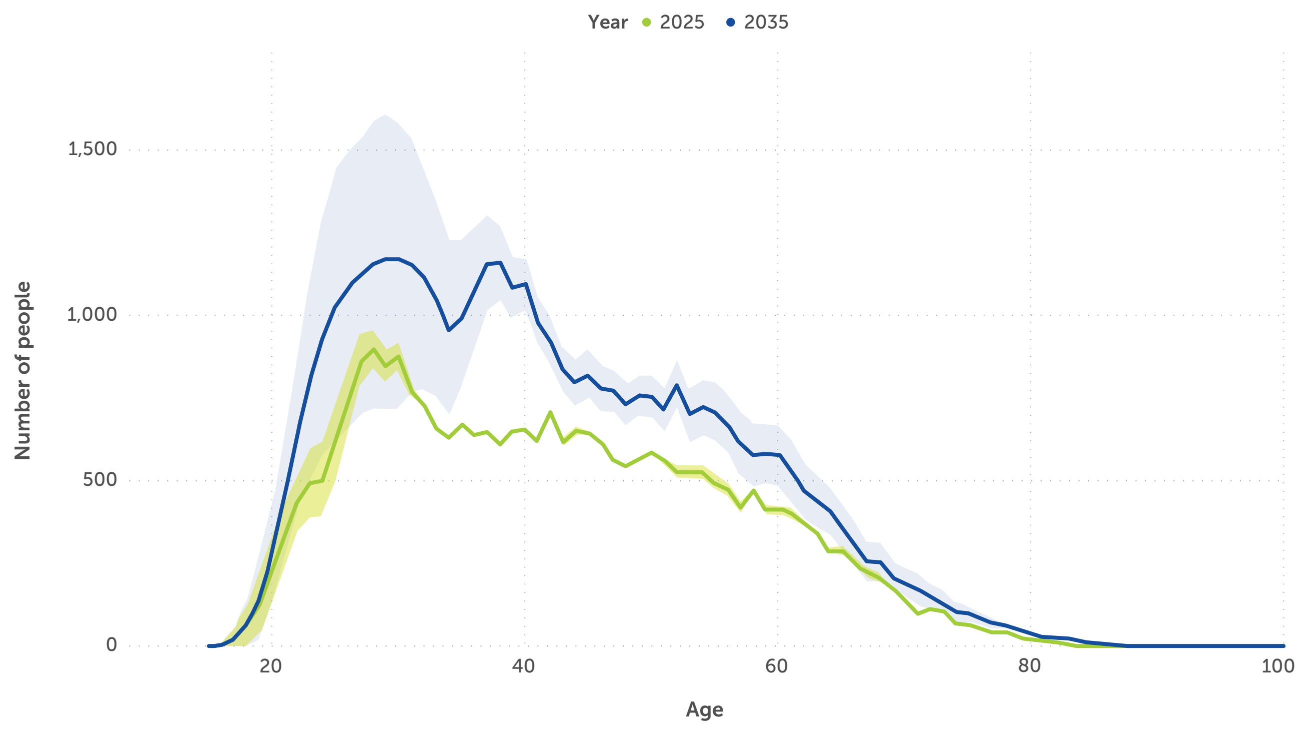
The teaching and research workforce in agriculture, environmental and related fields has grown, and there remains a shortage of agricultural research scientists in the broader workforce.

While business, higher education, and the private non-profit sectors have increased their investment in agricultural, veterinary and food sciences, government expenditure has declined.

Research output in agricultural science has increased, as measured by publication rates, while patent activity has remained stable.

Agriculture is projected to have an expansive workforce. However, the wide confidence interval is not conclusive as to whether this expansive workforce will be enough to meet national demand. The decrease in domestic enrolments suggests a need that may not be met.

**Figure 8** – Forecasted age distribution of the working population with a university qualification in agriculture in 2025 and 2035. Shaded areas represent 90% prediction intervals.




Read in more detail in Appendix C.

## Technological transformation

There is a growing need to reduce reliance on chemical pesticides to improve agricultural sustainability. Development of RNA-based technologies could provide more precise alternatives by specifically silencing genes within the target organism.

## Climate change, decarbonisation and environment

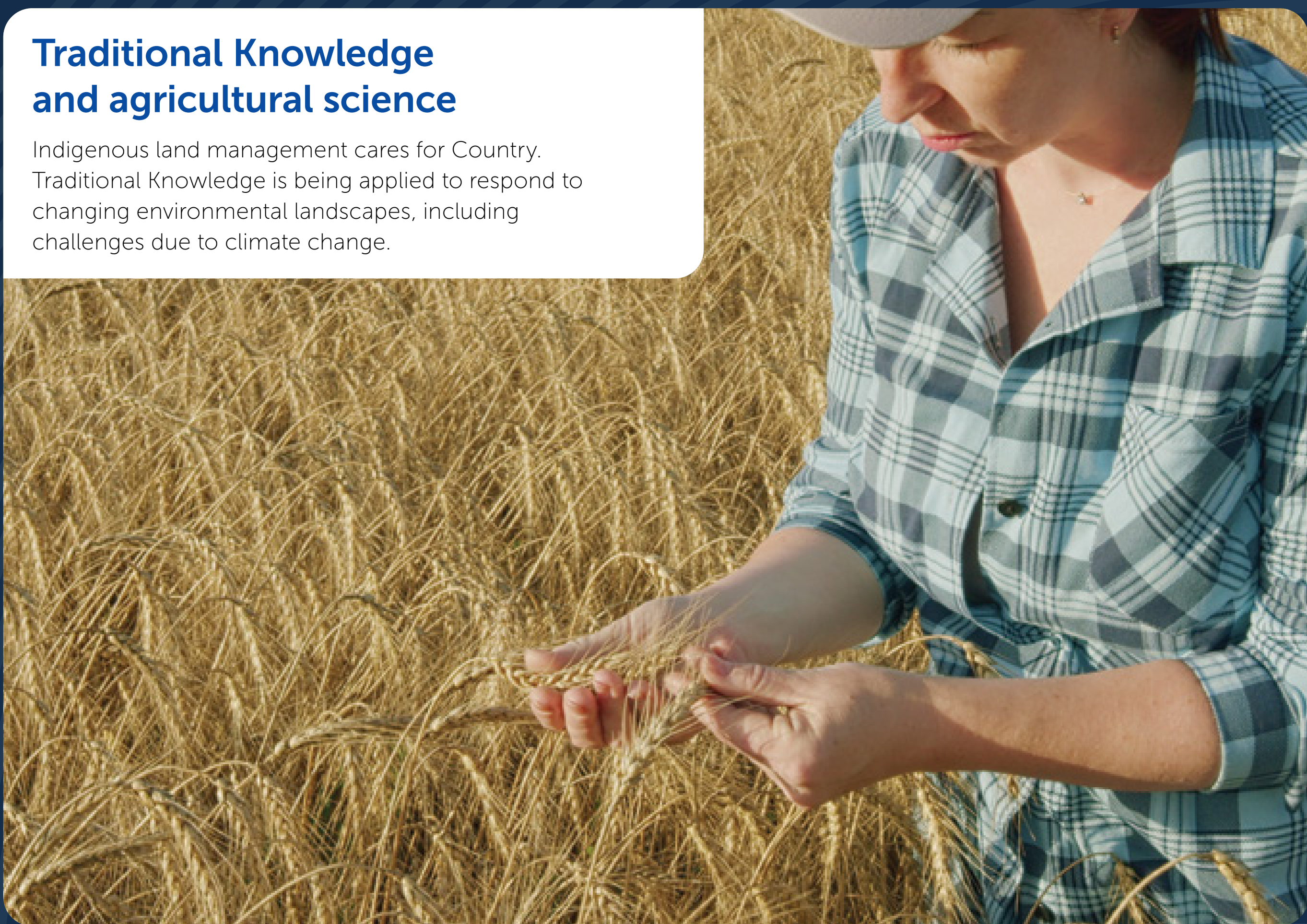
Farms will need to transition to net-zero greenhouse gas emissions. For example, cows produce methane when digesting their food. Anti-methanogenic feed additives (such as *Asparagopsis*, a red seaweed native to Australian coastal waters) can prevent methane production by competitively inhibiting the enzymatic pathway which produces methane at the last stage of digestion. Other approaches include improving carbon storage in soil and vegetation.[30]

## Demographic change

Australia's population is continuing to grow, and becoming more ethnically and culturally diverse. Additionally, Australia's ageing population is creating an environment with various complex chronic health conditions. This has increased demand for preventative healthcare, including better nutrition. As the agricultural landscape changes, it is important to ensure nutritional value of food supply is maintained.

## Traditional Knowledge and agricultural science

Indigenous land management cares for Country. Traditional Knowledge is being applied to respond to changing environmental landscapes, including challenges due to climate change.



# ARTIFICIAL INTELLIGENCE

## Underpinning fundamental science disciplines

CHEMISTRY | BIOLOGY | **MATHEMATICS** | PHYSICS

## What is AI?

The CSIRO defines artificial intelligence (AI) as 'a collection of interrelated technologies used to solve problems autonomously and perform tasks to achieve defined objectives without explicit guidance from a human being'.[31]

AI will be used to support research in multiple scientific disciplines, leading to high demand for scientists with AI skills.

## Data classification codes in scope

| | |
|---|---|
| **Learning areas**<br>*Australian Curriculum* | MATHEMATICS, TECHNOLOGY |
| **Fields of education**<br>*Australian Standard Classification of Education (ASCED)* | **CLOSEST MATCH**<br>• 02 Information technology<br>  o 0201 Computer science<br>    » 020119 Artificial intelligence<br>  o 0203 Information systems<br>    » 020307 Decision support systems<br>**UNDERPINNING OR CLOSELY RELATED FIELDS**<br>• 01 Natural and physical sciences<br>  o 0101 Mathematical sciences |
| **Fields of research**<br>*Australian and New Zealand Standard Research Classification (ANZSRC) 2020* | • 46 Information and computing sciences*<br>  o 4602 Artificial intelligence<br>  o 4603 Computer vision and multimedia computation<br>  o 4605 Data management and data science<br>  o 4611 Machine learning<br>*Note: Closest equivalent ANZSRC 2008 code used for R&D expenditure data (08 Information and computing sciences). |
| **Occupations**<br>*Australian and New Zealand Standard Classification of Occupations (ANZSCO)* | No direct ANZSCO match. |

## What is driving the demand for AI?

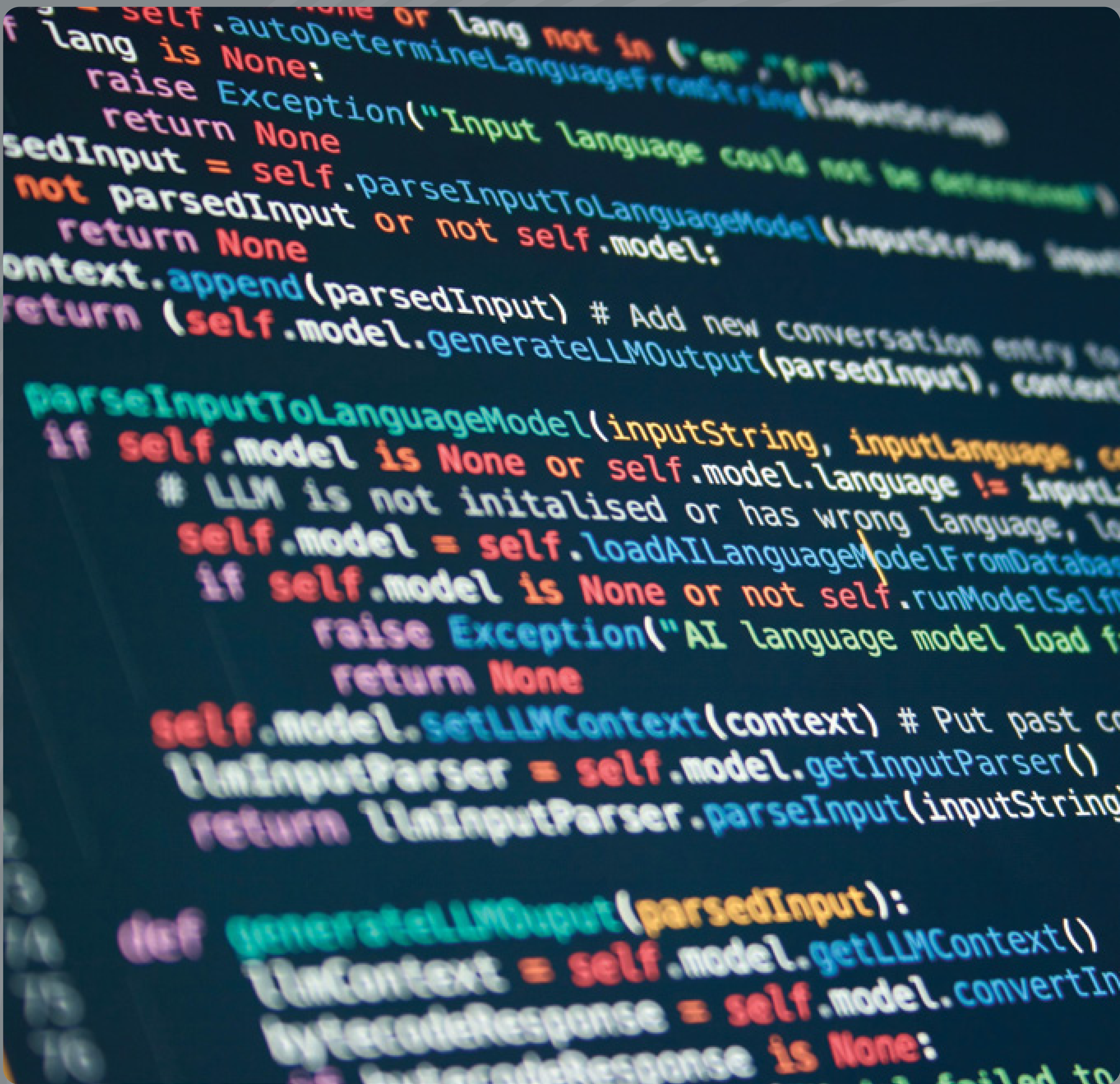
AI is an underpinning area for science – it is being used across multiple fields including food science, health, climate, agriculture, synthetic biology, RNA for agriculture, bioinformatics, and new medicine development.

AI can be used to aid decision-making in multiple areas and is transforming research. For example, administrative tasks such as academic writing can be performed more quickly, AI can augment and automate literature reviews, and analyse large datasets. AI tools are also widely used to accelerate brainstorming, support the development of code, and assist in building software applications.

Greater use of AI in Australian industries is predicted to create 200,000 jobs before 2030.

This demand will need to be met through a combination of entry-level training and re-skilling of existing workers.

Most AI tools used in Australia are based on large language models from the United States. These systems are trained on data that does not reflect Australia's cultural diversity, nor particulars of its context. Tailoring AI models to the Australian context requires Australian capability and expertise.



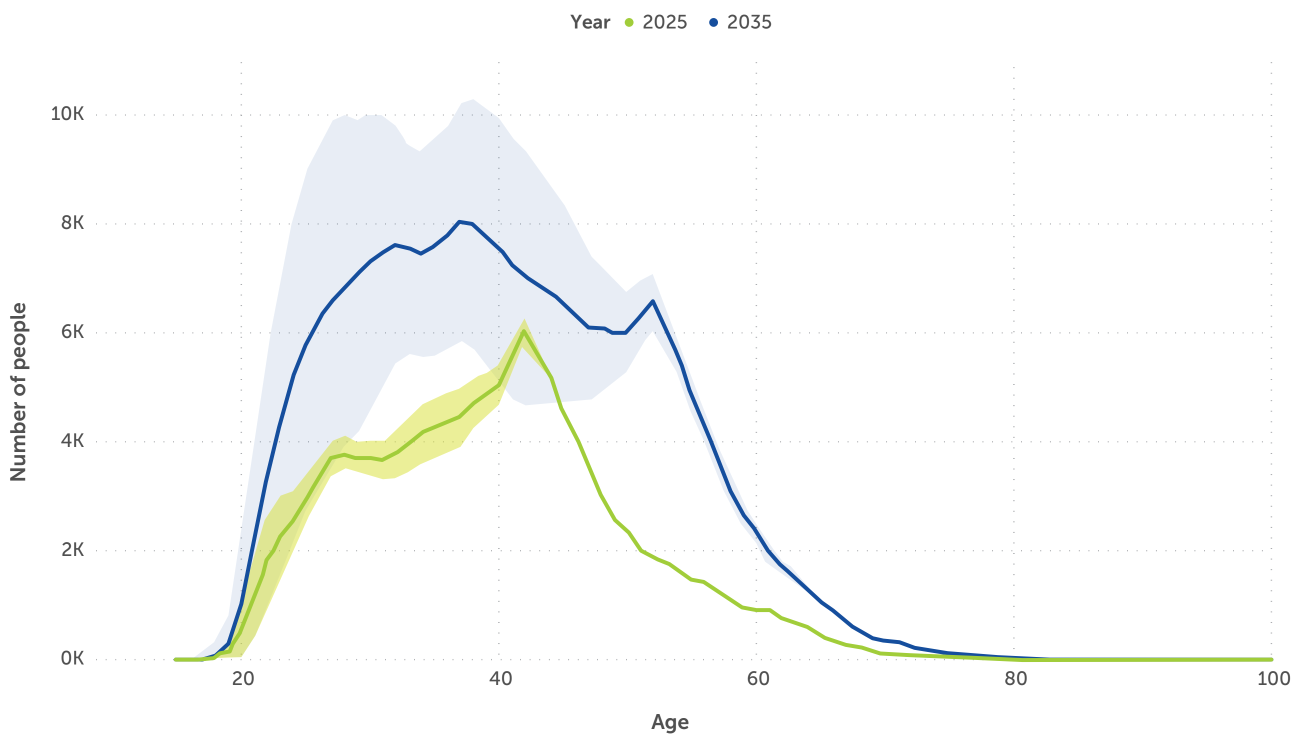
## Will Australia have sufficient capability to meet demand in AI?

Year 12 enrolments in information technology, physics, and astronomy have declined, while participation in mathematical sciences has remained similar, which could indicate a potential gap emerging.

At the tertiary level, undergraduate and postgraduate university completions in AI have increased, alongside growth in enrolments and completions in computer science. However, domestic postgraduate completions have recently fallen, particularly in the past few years.

The computer science workforce is projected to be expansive. Available data suggests the AI workforce is expanding, but this is not well captured in standard occupational classifications. There is no direct occupational category for AI, creating a gap in how we track and plan for this emerging capability.

**Figure 9** – Forecasted age distribution of the working population with a university qualification in computer science in 2025 and 2035. Shaded areas represent 90% prediction intervals.




The AI workforce is one undergoing substantial structural change, as it had low workforce numbers historically, and now is seeing greater numbers of entrants into the field. However, it is uncertain whether this growth will be sufficient to meet demand.

Research and development expenditure in information and computing sciences has increased across business, government, and higher education.

Australia's publications and patents in AI and machine learning are also on the rise, however the proportion of global publications is falling. This indicates that Australia is not keeping pace with other countries' growth in AI research.

Read in more detail in Appendix C.

## Climate change, decarbonisation and environment

AI is being used alongside Earth observation data to produce better information for local and state governments on heat island effects, guiding tree planting strategies to mitigate extreme heat at the street level, and providing future climate predictions. AI-driven analytics will be needed to deal with the data from satellites, to enable functions such as natural disaster responses.

## Technological transformation

AI can be used to screen materials for new applications. For example, finding materials that can absorb carbon dioxide efficiently for direct air capture.[32]

## Demographic change

AI has the potential to support healthcare staff by automating routine tasks, completing administrative work such as note-taking, and supporting decision-making. In Australia today, AI is being used to write clinical notes, support finding diagnoses by integrating a range of data modalities (e.g. text and images), and find new treatments for antimicrobial resistance.

CASE STUDY

## Traditional Knowledge and AI

In Kakadu, AI is being used to care for Country, resulting in the return of thousands of magpie geese through the collection and analysis of data, identification, and drone monitoring.[33]

EDUCATION | WORKFORCE | FUNDING | RESEARCH OUTPUT

# BIOTECHNOLOGY

## Underpinning fundamental science disciplines

CHEMISTRY | BIOLOGY | MATHEMATICS | PHYSICS

## What is biotechnology?

Biotechnology is often referred to as technology based on basic biology. It engineers processes from biological systems to develop products and materials for various applications.

## Data classification codes in scope

| | |
|---|---|
| **Learning areas**<br>*Australian Curriculum* | SCIENCE<br>TECHNOLOGY |
| **Fields of education**<br>*Australian Standard Classification of Education (ASCED)* | **CLOSEST MATCH**<br>• 01 Natural and physical sciences<br>  ○ 0199 Other natural and physical sciences<br>    » 019905 Food science and biotechnology<br><br>**UNDERPINNING OR CLOSELY RELATED FIELDS**<br>• 01 Natural and physical sciences<br>  ○ 0105 Chemical sciences<br>  ○ 0109 Biological sciences |
| **Fields of research**<br>*Australian and New Zealand Standard Research Classification (ANZSRC) 2020* | • 30 Agricultural, veterinary and food sciences*<br>  ○ 3001 Agricultural biotechnology<br>• 31 Biological sciences*<br>  ○ 3106 Industrial biotechnology<br>• 32 Biomedical and clinical sciences*<br>  ○ 3206 Medical biotechnology<br>• 41 Environmental Sciences*<br>  ○ 4103 Environmental biotechnology<br><br>*R&D expenditure data is not provided for this capability. Relevant subcodes previously sat under 10 Technology in ANZSRC 2008. There is no equivalent code in ANZSRC 2020. |
| **Occupations**<br>*Australian and New Zealand Standard Classification of Occupations (ANZSCO)* | ANZSCO 2022 and ANZSCO 2013 V1.3<br>• 234 Natural and physical science professionals<br>  ○ 2345 Life scientists<br>    » 234514 Biotechnologist |

## What is driving demand for biotechnology?

Biotechnology is globally recognised as a critical technology. There is a need for local expertise to harness its value for Australia. Biotechnology draws from engineering and other technologies as knowledge is converted to products and services.

Key areas in demand will be:

- medical biotechnology
  (e.g. developing drugs, diagnostics and therapies)
- agricultural biotechnology
  (e.g. pest and disease-resistant crops)
- industrial biotechnology
  (e.g. producing bio-based materials)
- environmental biotechnology
  (e.g. for waste management).

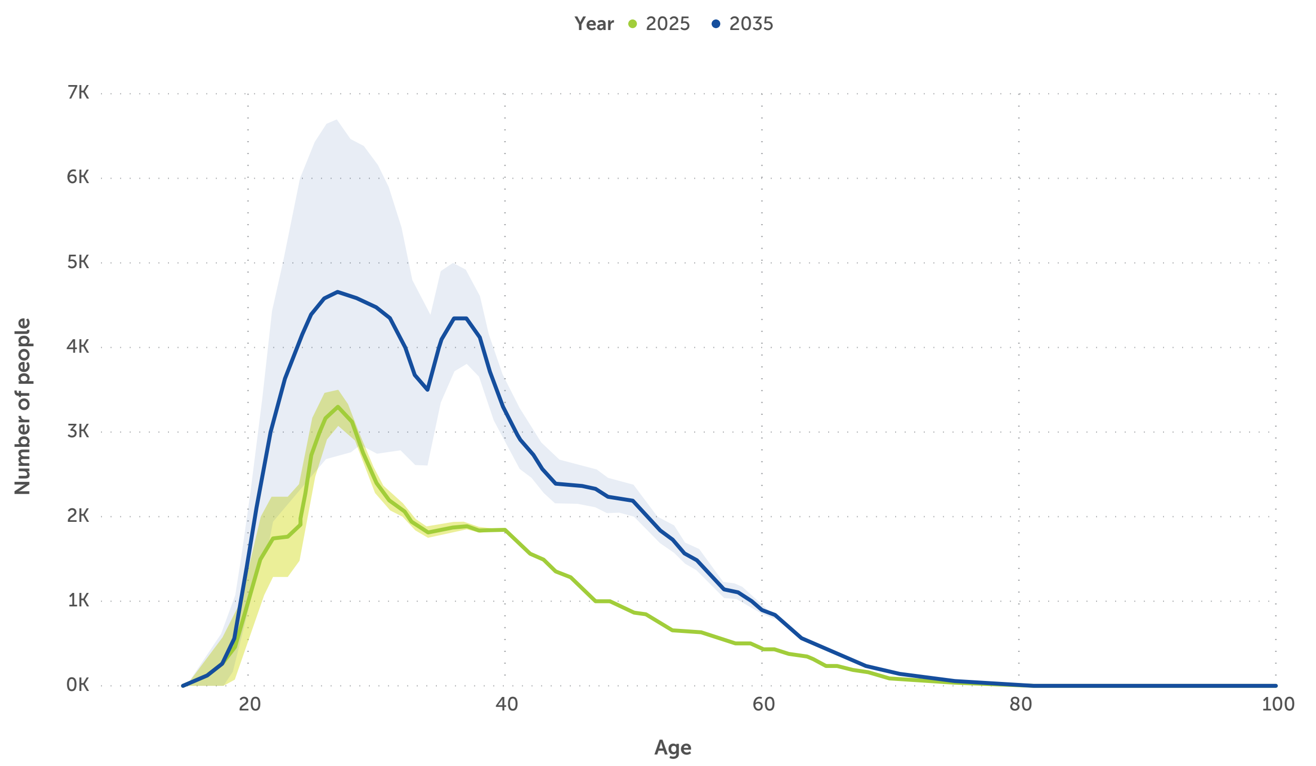
## Will Australia have sufficient capability to meet demand in biotechnology?

Year 12 enrolments in the biological sciences have increased, while enrolments in chemical sciences and other natural and physical sciences, including biotechnology, have declined.

At the tertiary level, growth in food science and biotechnology graduates suggests capability is developing, though lack of Field of Education classification codes specific to biotechnology make it impossible to track progress with confidence.

While there are no declared shortages of biotechnologists, workforce data are limited and migration figures are too small to draw firm conclusions. Projections indicate workforce growth across the broader field called other natural and physical sciences, though this is not specific to just biotechnology.

**Figure 10** – Forecasted age distribution of the working population with a university qualification in other natural and physical sciences in 2025 and 2035. Shaded areas represent 90% prediction intervals



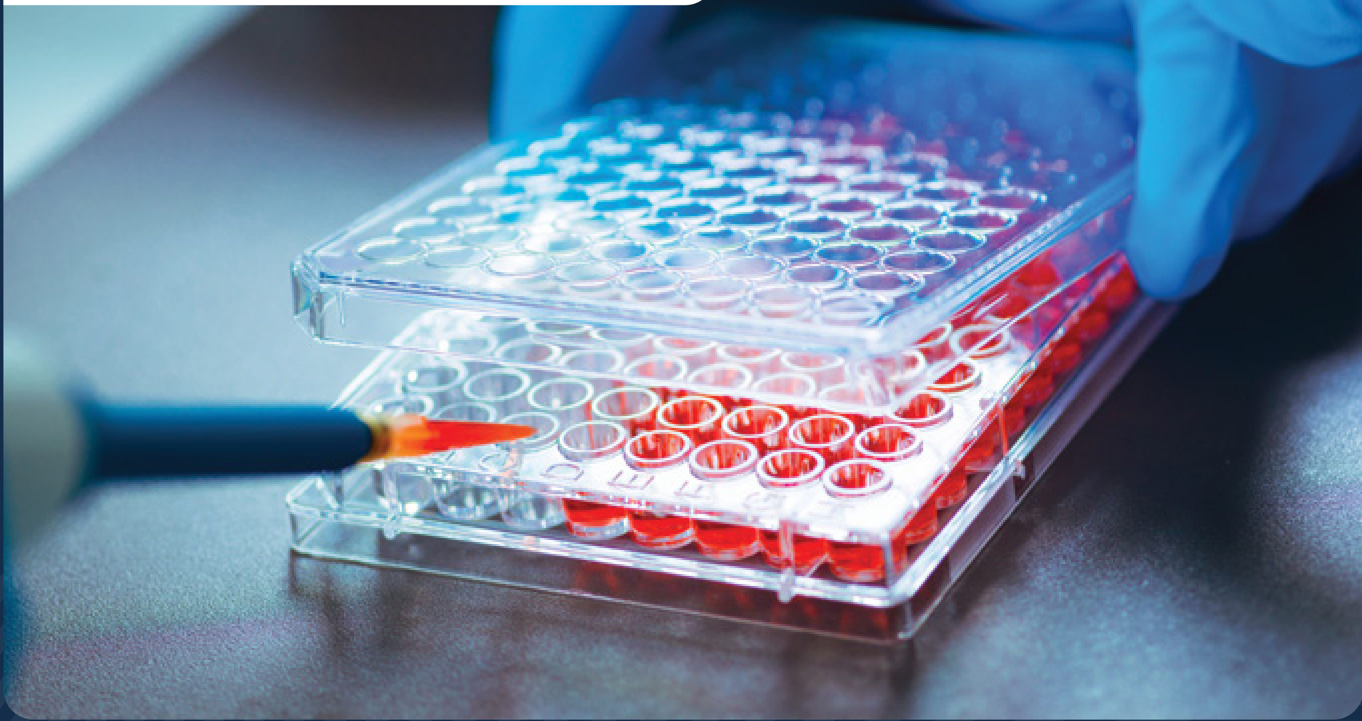

On the research front, Australian publications and patents in biotechnology have increased or remained steady, but trends in R&D investment are harder to assess due to changes in the way biotechnology has changed within Field of Research codes over the past decade.

This lack of clarity – across both education and research data – makes it increasingly difficult to monitor a capability area that will be central to Australia's health, environmental and economic ambitions in the decades ahead.

**Read in more detail in Appendix C.**

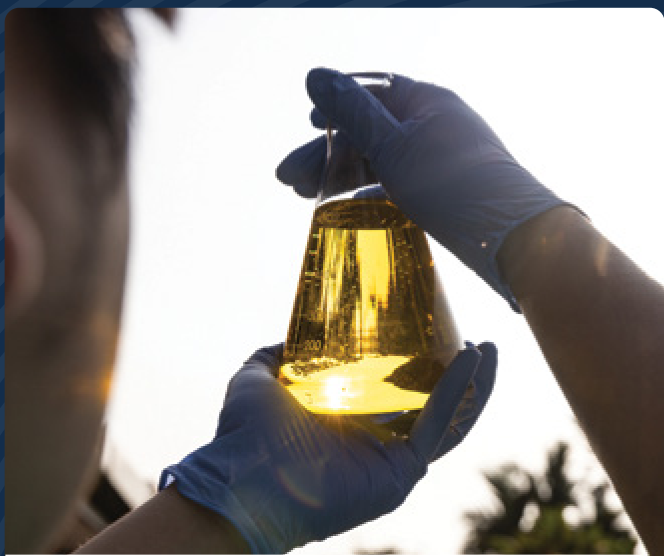
## Technological transformation

Biotechnology has led to the development of advanced diagnostic tools and precision therapies improving preventative healthcare models and reducing burden on the overall health system. There is a need for local expertise to harness new technological transformation in Australia.



## Demographic change

Biotechnology can be used to develop new medical treatments – including neurological conditions such as Alzheimer's disease, Parkinson's disease and motor neurone disease.



## Climate change, decarbonisation and environment

Engineered microbes that convert biomass to biofuels will reduce reliance on fossil fuels.

# CLIMATE SCIENCE

## Underpinning fundamental science disciplines

CHEMISTRY | BIOLOGY | MATHEMATICS | PHYSICS

## What is climate science?

Climate science draws upon all fundamental disciplines of science and studies weather and climate, how it is changing, and how it will change in the future, including data, process-based understanding and modelling.

## Data classification codes in scope

| | |
|---|---|
| **Learning areas**<br>*Australian Curriculum* | MATHEMATICS · SCIENCE |
| **Fields of education**<br>*Australian Standard Classification of Education (ASCED)* | **CLOSEST MATCH**<br>• 01 Natural and physical sciences<br>o 0107 Earth sciences<br>» 010701 Atmospheric sciences<br>» 010709 Soil science<br>» 010713 Oceanography<br><br>**UNDERPINNING OR CLOSELY RELATED FIELDS**<br>• 01 Natural and physical sciences<br>o 0104 Physics and astronomy<br>o 0105 Chemical sciences<br>o 0109 Biological sciences<br>• 02 Information technology<br>o 0201 Computer science |
| **Fields of research**<br>*Australian and New Zealand Standard Research Classification (ANZSRC) 2020* | • 37 Earth sciences*<br>o 3701 Atmospheric sciences<br>o 3702 Climate change science<br>o 3708 Oceanography<br>o 3799 Other Earth sciences (includes 379901 Earth system sciences)<br>• 41 Environmental sciences*<br>o 4101 Climate change impacts and adaptation<br>o 4106 Soil sciences<br><br>*Note: Closest equivalent ANZSRC 2008 code used for R&D expenditure data (04 Earth sciences and 05 Environmental sciences). |
| **Occupations**<br>*Australian and New Zealand Standard Classification of Occupations (ANZSCO)* | No direct ANZSCO match. |

## What is driving the demand for climate science?

Climate change is a threat to our environment and way of life.

Australia must adapt to mitigate the impact of planetary warming while working with the global community to reduce greenhouse gas emissions.

Australia requires expertise in climate science to undertake the climate transition effectively, and to manage risks during this transition, particularly in areas related to energy, adaptation, mitigation, water resource management, carbon management, and agriculture.

Climate science is a critical input to developing future climate predictions as well as adaptation and mitigation strategies.

## Will Australia have sufficient capability to meet demand in climate science?

Enrolments in Earth science and biological sciences have increased, while physics and astronomy, chemistry and information technology have seen declines.

VET enrolments and domestic university enrolments and completions in Earth sciences at both undergraduate and postgraduate levels are in decline. The number of university graduates in atmospheric sciences has remained similar, while graduates in soil science and oceanography have increased. Climate science may also be captured under physical science and mathematical science.

Climate science is not well captured in current occupation classification systems. There is no direct occupational category for climate scientists, making workforce planning and capability monitoring difficult. As noted in the Academy's *Decadal plan for Earth system science 2024–2033*, demand is rising, particularly as businesses begin to grapple with climate risk, yet workforce planning has not kept pace.

Research publications in climate science have increased. There are few patents, which is to be expected given the nature of the field.

Care should be taken in interpreting trends in Earth sciences as an indicator for climate science capability, as declining trends in geoscience may disguise patterns in climate science (*see Geoscience capability chapter*).

**Read in more detail in Appendix C.**

## Technological transformation

The rapid expansion of AI has potential impacts on the climate. AI is very resource intensive, requiring large amounts of water and energy. Consumption of energy by data centres has doubled energy usage. Climate science will be needed to understand the impact of AI on Australia's climate. AI will also be used to support climate research.

## Climate change, decarbonisation and environment

Australia's unique ecology and hypervariable environment (e.g. rainfall, arid systems) require locally developed models, not Northern Hemisphere models. Australia needs to know with much better spatial resolution and accuracy what the future is going to hold (e.g. whether it will be wetter or drier, the frequency or magnitude of extreme events, the likelihood of passing a tipping point). This will require improving our national modelling system to address known biases and to enhance capability. This will enable better climate predictions that can be shared with the climate-sensitive sectors of the Australian economy and society – such as water, food, energy, health, transport, and infrastructure.

## Demographic change

Climate science is needed to inform urban planning. Too often, responses focus on past disasters rather than preparing for future risks. Climate science will underpin the analysis and evaluation of threats posed by future severe weather events and natural disasters.

CASE STUDY

## Traditional Knowledge and agricultural science

Indigenous peoples have adapted to a changing Great Barrier Reef, although the present rate of change is unprecedented. Traditional Knowledge could provide a framework for manageing a changing and adapting Great Barrier Reef, taking a holistic view and blurring the boundaries between land and sea.[34] In the Reef Futures Roundtables in 2023, Traditional Owners noted there is opportunity to address the decline of the Great Barrier Reef values in a more profound and connected way, using a collaborative approach founded in Traditional Knowledges.[35]

EDUCATION | WORKFORCE | FUNDING | RESEARCH OUTPUT

# DATA SCIENCE

## Underpinning fundamental science disciplines

CHEMISTRY | BIOLOGY | MATHEMATICS | PHYSICS

## What is data science?

Data science covers methods and computing systems for working with datasets. Data science is multidisciplinary, including computer science and mathematical sciences (e.g. statistical science).

Data science is a capability of value to most scientific disciplines. This expertise is required to manage, secure, and use Australian and international data across diverse applications.

## Data classification codes in scope

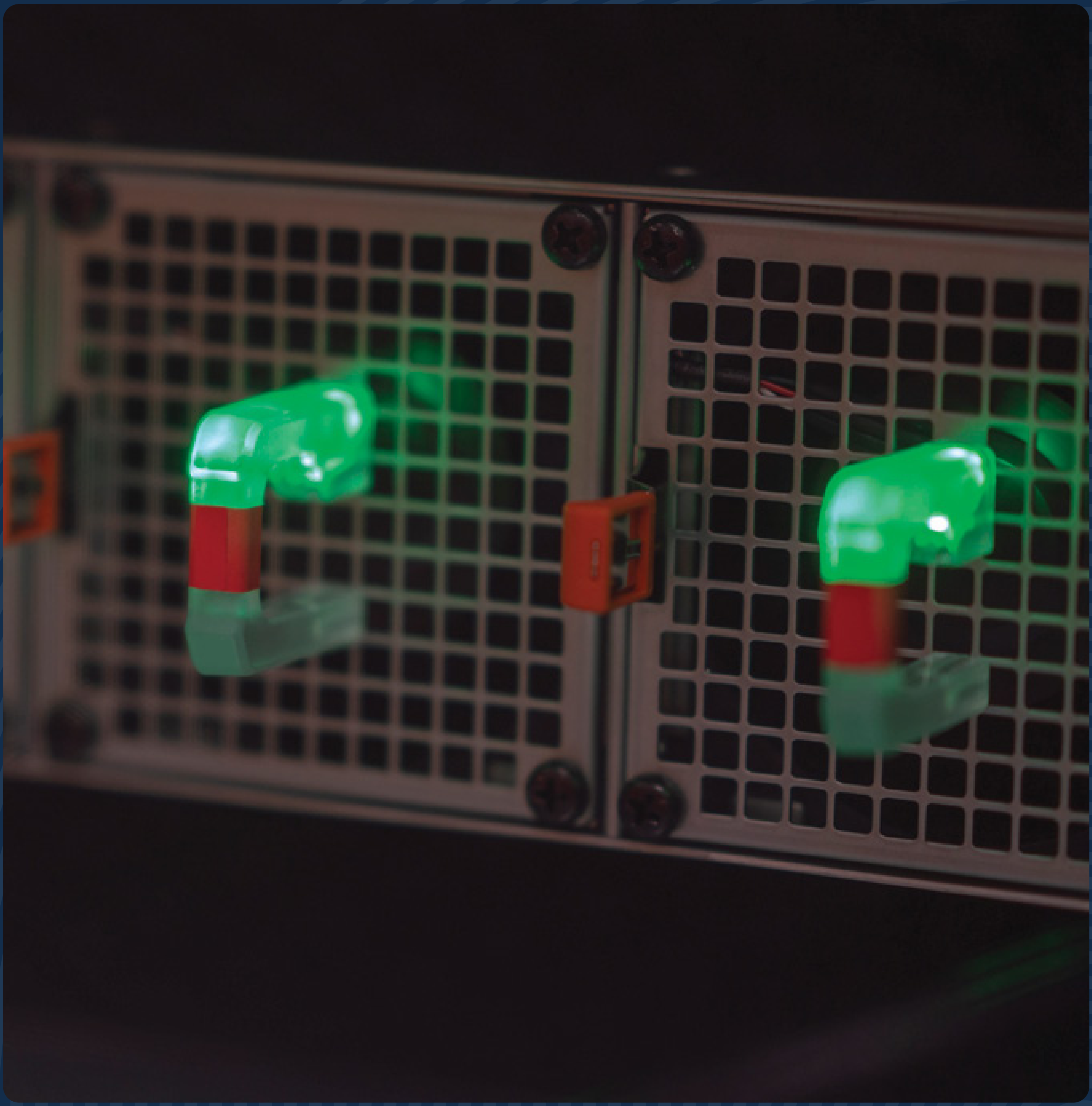
| | |
|---|---|
| **Learning areas**<br>*Australian Curriculum* | MATHEMATICS<br>TECHNOLOGY |
| **Fields of education**<br>*Australian Standard Classification of Education (ASCED)* | **CLOSEST MATCH**<br>• 01 Natural and physical sciences<br>  o 0101 Mathematical sciences<br>    » 010103 Statistics<br>• 02 Information technology<br>  o 0201 Computer science<br>    » 020111 Data structures<br>  o 0203 Information systems<br>    » 020303 Database management |
| **Fields of research**<br>*Australian and New Zealand Standard Research Classification (ANZSRC) 2020* | • 49 Mathematical sciences<br>  o 4905 Statistics<br>    » 490508 Statistical data science<br>• 46 Information and computing sciences<br>  o 4605 Data management and data science<br>*Closest equivalent ANZSRC 2008 code used for R&D expenditure data (01 Mathematical sciences and 08 Information and computing sciences). |
| **Occupations**<br>*Australian and New Zealand Standard Classification of Occupations (ANZSCO)* | ANZSCO 2022<br>• 224 Information and organisation professionals<br>  o 2241 Mathematical science professionals<br>    » 224114 Data analyst<br>    » 224115 Data scientist<br>    » 224116 Statistician<br>ANZSCO 2013 V1.3<br>• 224 Information and organisation professionals<br>  o 2241 Actuaries, mathematicians and statisticians<br>    » 224113 Statistician |

## What is driving the demand for data science?

Australia already lacks sufficient data analytics capacity and supporting infrastructure. High-performance computing and data (HPCD) infrastructure will be critical to Australia's research and development capability in the next decade. Australia is also limited by its internet connectivity and speed.

This capability is needed to establish and sustain data sovereignty across many sectors of the economy (e.g. Australian climate and biodiversity data, health) and to support the uptake and creation of AI tools for the Australian context.

It is imperative that Australia maintains a highly trained workforce with a critical mindset – data needs to be available, interrogated, critiqued and adopted where relevant.



## Will Australia have sufficient capability to meet demand in data science?

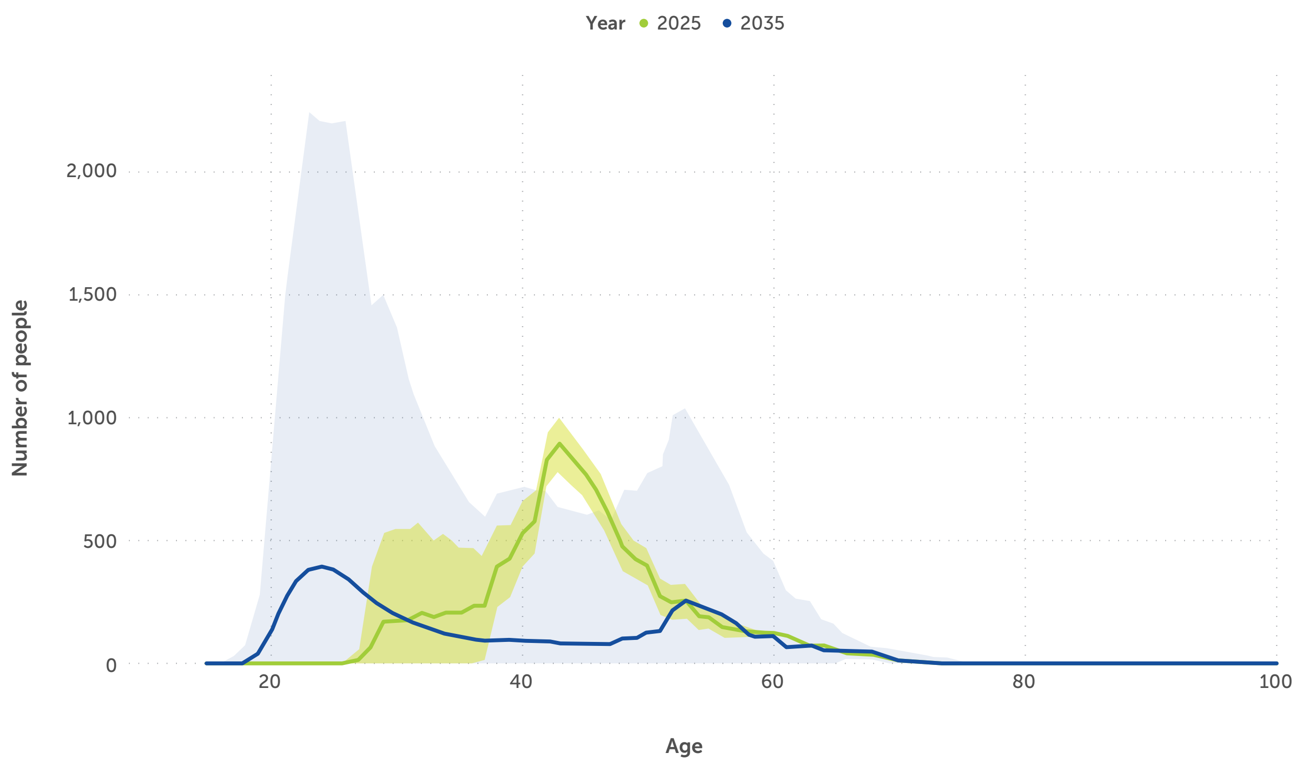
Participation in technology and information technology at Year 12 has declined, as have VET enrolments in computer science – despite rising demand for digital capability across sectors.

Enrolments in both information systems at the VET level and at the undergraduate level have grown, while postgraduate figures have remained steady.

In several states and territories, there are now identified shortages of mathematical science professionals, data analysts, and data scientists – roles that are also increasingly essential as enablers for other science disciplines.

Workforce projections point to expansion in computer science and the mathematical sciences jobs. The projection for the information systems workforce remains uncertain.

**Figure 11** – Forecasted age distribution of the working population with a university qualification in information systems in 2025 and 2035. Shaded areas represent 90% prediction intervals




The data science workforce had small pre-existing numbers and is experiencing a large influx of graduates.

Research outputs show publications in data science and data management are increasing, while output in statistics has remained stable.

**Read in more detail in Appendix C.**

## Technological transformation

Data science can be applied to logistics and supply chains. It will make supply more consistent and predictable, with less environmental footprint.

Credit: Jamie Kidston/ANU

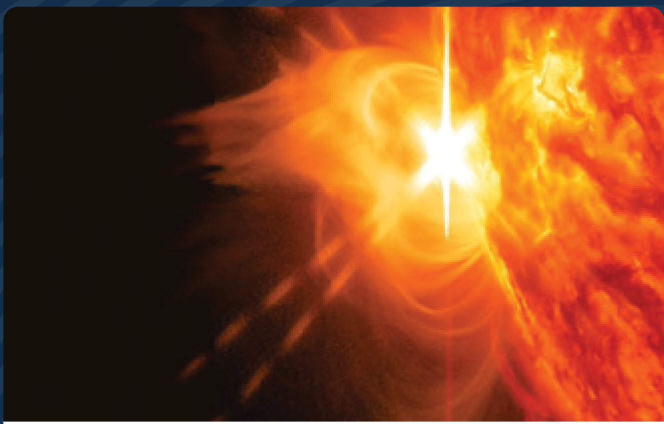
## Demographic change

Data streams such as population health surveys will enable Australian researchers to better understand the prevalence of chronic conditions and how these become more complex as people age.

CASE STUDY

## Indigenous data sovereignty

Indigenous data sovereignty is the right of Indigenous Peoples to own, control, access and possess data that derive from them, and which pertain to their members, knowledge systems, customs, resources or territories. Data protocols like CARE (Collective benefit, Authority to control, Responsibility, Ethics) principles provide a framework for researchers looking to engage with Indigenous Knowledges and Indigenous Knowledge Holders.



## Climate change, decarbonisation and environment

Data science is needed for algorithms and analyses in space science, for example tracking carbon dioxide emissions. Space weather research is critical for being prepared for adverse weather events in Australia such as bushfires.

# EPIDEMIOLOGY

## Underpinning fundamental science disciplines

CHEMISTRY | **BIOLOGY** | **MATHEMATICS** | PHYSICS

## What is epidemiology?

Epidemiology investigates all factors that determine the presence or absence of disease or disorders. It determines how many people are living with a disease, if that number is changing, and how the disease affects communities and our wider society.

Clinical epidemiology applies epidemiologic principles to the individual patient to improve diagnosis and disease management.

## Data classification codes in scope

| | |
|---|---|
| **Learning areas**<br>*Australian Curriculum* | MATHEMATICS · SCIENCE |
| **Fields of education**<br>*Australian Standard Classification of Education (ASCED)* | **CLOSEST MATCH**<br>• 06 Health<br>o 0613 Public health<br>» 061311 Epidemiology<br><br>**UNDERPINNING OR CLOSELY RELATED FIELDS**<br>• 01 Natural and physical sciences<br>o 0101 Mathematical sciences<br>o 0109 Biological sciences |
| **Fields of research**<br>*Australian and New Zealand Standard Research Classification (ANZSRC) 2020* | • 42 Health sciences*<br>o 4202 Epidemiology<br><br>*Closest equivalent ANZSRC 2008 code used for 2012 R&D expenditure data (11 Medical and health sciences). It is compared to the combined 2022 R&D expenditure for 42 Health sciences and 32 Biomedical and clinical sciences.<br><br>Note: There are epidemiology codes under 45 Indigenous studies and 30 Agricultural, veterinary and food sciences but were not analysed due to limited data availability:<br>• 300905 Veterinary epidemiology<br>• 450406 Aboriginal and Torres Strait Islander epidemiology<br>• 451005 Te mātai tahumaero o te Māori (Māori epidemiology)<br>• 451605 Pacific Peoples epidemiology |
| **Occupations**<br>*Australian and New Zealand Standard Classification of Occupations (ANZSCO)* | No direct ANZSCO match.<br><br>ANZSCO 2022 and ANZSCO 2013 V1.3<br>• 253399 Specialist physicians not elsewhere classified (includes public health physicians) |

## What is driving the demand for epidemiology?

A complicated and interconnected world means that the health of populations is also connected: epidemics, pandemics, and parameters such as climate change, and population ageing all impact on local communities.

Epidemiological expertise is integral to population health. It is involved directly in clinical trials, observational studies, synthesis of evidence and guidelines, and the converting of evidence into practice. Capability is essential to both prevent disease transmission and to control any disease outbreaks.

Workshop participants emphasised:

- an increased need for epidemiologists to support health care for an ageing population with chronic health conditions
- environmental epidemiology to consider the impact of climate change on Australians' health (e.g. increased extreme weather events, air pollution, water quality)
- the nuances of personalised medicine adopted into routine clinical care
- demand for environmental epidemiologists (impacts of climate change on health), genetic epidemiologists (personalised medicine), and clinical epidemiologists (ensuring best clinical practice and high-quality clinical studies)
- current shortage of clinical epidemiologists, and no contingency plans for an ageing workforce.

## Will Australia have sufficient capability to meet demand in epidemiology?

There is uncertainty regarding gaps in epidemiology capability.

Enrolments in relevant Year 12 subjects mathematics and science have remained steady.

While VET and undergraduate enrolments and completions in public health have remained steady or declined, postgraduate enrolments and completions have increased – suggesting growing interest at more advanced levels of study.

There is no direct ANZSCO match for epidemiologists. There are Australia-wide shortages of specialist physicians (not elsewhere classified). However, this occupation code includes fields other than epidemiology.

No age structure analysis was performed for epidemiology to forecast future workforce due to the lack of relevant data codes to perform meaningful analysis.

R&D expenditure relevant to epidemiology has increased or remained similar. Research activity in the field is growing, as reflected in the increase in epidemiology publications. Patent activity remains limited, and less relevant given the nature of the discipline.

Read in more detail in Appendix C.

## Demographic change

Epidemiologists are needed to help understand how diseases spread. These diseases can be particularly dangerous for older people or those living with chronic diseases. For example, there has been a recent outbreak of meliodosis (a soil-borne disease) in Queensland. Melioidosis tends to affect older people, those with immune problems, or those with diseases like diabetes and kidney disease. Epidemiologists are part of the team tracing this disease outbreak, which has been linked to floodwater and construction works.

CASE STUDY

## Epidemiology and health outcomes for Aboriginal and Torres Strait Islander people

There are differences in the prevalence of certain conditions depending on ethnicity (e.g. the rate of type 2 diabetes is twice as high among Indigenous Australians). The National Agreement on Closing the Gap is intended to have an impact on life outcomes for Aboriginal and Torres Strait Islander people. The first target is to close the gap in life expectancy within a generation, by 2031. Working to achieve this goal will require evidence-informed action – and that requires epidemiology.

## Climate change, decarbonisation and environment

Climate change increases the risk of zoonotic diseases (infectious diseases that can be transmitted between humans and animals). For example, floodwater can increase the number of mosquitoes that can transmit diseases.

## Technological transformation

AI can be used to analyse large volumes of data, this allows epidemiologists to detect patterns, predict outbreaks, and inform targeted interventions more accurately.

CASE STUDY

## Traditional Knowledges and the One Health approach

A healthy environment supports public health in a myriad of ways (e.g. clean air and water, improved mental health). The One Health approach recognises the inherent interconnectedness between humans, animals, and environmental health that has been understood by Indigenous Australians for thousands of years.

EDUCATION | WORKFORCE | FUNDING | RESEARCH OUTPUT

# GEOSCIENCE

## Underpinning fundamental science disciplines

CHEMISTRY | BIOLOGY | MATHEMATICS | PHYSICS

## What is geoscience?

Geoscience covers Earth's physical processes and composition. It encompasses traditional disciplines such as geology, geophysics, and geochemistry, as well as satellite positioning, surveying, spatial science, marine science, Antarctic geoscience, Earthquake monitoring, and Earth observation.

Geoscience informs the discovery, extraction, and sustainable utilisation of finite resources including the diverse minerals required to decarbonise the economy and to support technological development.

## Data classification codes in scope

| | |
|---|---|
| **Learning areas**<br>*Australian Curriculum* | SCIENCE<br>MATHEMATICS |
| **Fields of education**<br>*Australian Standard Classification of Education (ASCED)* | **CLOSEST MATCH**<br>• 01 Natural and physical sciences<br>o 0107 Earth Sciences<br>» 010703 Geology<br>» 010705 Geophysics<br>» 010707 Geochemistry<br>» 010711 Hydrology<br>• 03 Engineering and related technologies<br>o 0311 Geomatic engineering<br>» 031101 Surveying<br>» 031103 Mapping science<br>» 031199 Geomatic engineering, nec<br><br>**UNDERPINNING OR CLOSELY RELATED FIELDS**<br>• 01 Natural and physical sciences<br>o 0101 Mathematical sciences<br>o 0103 Physics and astronomy<br>» 010301 Physics<br>o 0105 Chemical sciences |
| **Fields of research**<br>*Australian and New Zealand Standard Research Classification (ANZSRC) 2020* | • 37 Earth Sciences*<br>o 3703 Geochemistry<br>o 3704 Geoinformatics<br>o 3705 Geology<br>o 3706 Geophysics (includes 370603 Geodesy)<br>o 3707 Hydrology<br>o 3709 Physical geography and environmental geoscience<br>• 40 Engineering<br>o 4013 Geomatic engineering<br>*Note: Closest equivalent ANZSRC 2008 code used for R&D expenditure data (04 Earth sciences and 09 Engineering). |

**Occupations**
*Australian and New Zealand Standard Classification of Occupations (ANZSCO)*

**ANZSCO 2022 and ANZSCO 2013 V1.3**

- 232 Architects, designers, planners and surveyors
  - 2322 Surveyors and spatial scientists
    - 232212 Surveyor
    - 232213 Cartographer
    - 232214 Other spatial scientist
- 234 Natural and physical science professionals
  - 2344 Geologists, geophysicists and hydrogeologists
    - 234411 Geologist
    - 234412 Geophysicist
    - 234413 Hydrogeologist

## What is driving the demand for geoscience?

Geoscience is required for mining, critical minerals, groundwater management, Earthquake monitoring, satellite location services, supporting the transition to net zero, carbon management, and understanding environmental changes.

Expertise in geoscience can be seen as fossil fuel-related, but this capability will be important for transitioning those industries to new fields such as geothermal energy, carbon management and underground energy storage. Australia is heavily reliant on overseas sources to address these skill shortages.

EDUCATION WORKFORCE FUNDING RESEARCH OUTPUT

## Will Australia have sufficient capability to meet demand in geoscience?

The geoscience capability pipeline in Australia is weak.

Year 12 enrolments remained stable, albeit with small numbers (4,444 Year 12 enrolments in Earth sciences compared to 36,516 in chemical sciences and 25,984 in physics and astronomy in 2023).

Undergraduate and postgraduate completions have fallen, and no recent data are available on VET completions.

Workforce shortages in geology and geophysics have been identified at a national level.

The impact of shortages will be compounded by the ageing profile of the current Earth science workforce, and by a drop in skilled permanent migration for geologists and geophysicists.

**Figure 12** – Forecasted age distribution of the working population with a university qualification in Earth sciences in 2025 and 2035. Shaded areas represent 90% prediction intervals


Observed trends may understate the scale of the loss. Recent structural changes in the higher education sector, including the closure of Earth science departments and the discontinuation of undergraduate majors, occurred after the period covered by much of this data.

**Read in more detail in Appendix C.**

## Technological transformation

The Southern Positioning Augmentation Network (SouthPAN) is a joint initiative of the Australian and New Zealand governments that provides satellite-based augmentation system services for Australia and New Zealand. SouthPAN is comprised of reference stations, telecommunications infrastructure, computing centres, signal generators, and satellites that provide improved positioning and navigation services. This improved positioning technology has economic, social and environmental benefits across 10 different industry sectors (agriculture, aviation, construction, consumer, resources, road, rail, maritime, mining and utilities).

## Demographic change

Australia's population is expected to grow from 27 million to 30.9 million people in the next decade. This growth will place greater demands on infrastructure such as transport and energy. Geoscience provides the resources needed to build and sustain these systems.

## Mining and Indigenous land

CASE STUDY

The global energy transition has increased demand for the critical minerals needed in the production of batteries, solar panels and other renewable energy technology. More than half of Australia's critical minerals lie within formally recognised Indigenous lands.

## Climate change, decarbonisation and environment

Understanding Australia's mineral resources is necessary to support the transition to net zero and achieve a clean energy future. The Future Made in Australia initiative has invested $566.1 million over 10 years, starting from 2024–25 into Geoscience Australia to deliver data, maps and other tools for use by the resources industry – but we already have a skills shortage.

# MATERIALS SCIENCE

## Underpinning fundamental science disciplines

CHEMISTRY | BIOLOGY | MATHEMATICS | PHYSICS

## What is materials science?

Materials science is multidisciplinary. It studies the properties, structure, processing, and performance of materials, focusing on how a material's composition and internal structure determine its behaviour and potential uses.

It designs, creates, and improves materials for a wide range of applications, such as electronics, medicine, aerospace, and energy.

## Data classification codes in scope

**Learning areas**
*Australian Curriculum*

MATHEMATICS | SCIENCE

**Fields of education**
*Australian Standard Classification of Education (ASCED)*

**CLOSEST MATCH**

- 01 Natural and physical sciences
  - 0105 Chemical sciences
    - 010501 Organic chemistry
    - 010503 Inorganic chemistry
    - 010599 Chemical sciences, nec
  - o 0103 Physics and astronomy
    - 010301 Physics
- 03 Engineering and related technologies
  - 0303 Process and resources engineering
    - 030301 Chemical engineering
    - 030305 Materials engineering

**UNDERPINNING OR CLOSELY RELATED FIELDS (FOR YEAR 12 ENROLMENTS ONLY)**

- 01 Natural and physical sciences
  - 0101 Mathematical sciences
  - 0109 Biological sciences

| | |
|---|---|
| **Fields of research**<br>*Australian and New Zealand Standard Research Classification (ANZSRC) 2020* | • 34 Chemical sciences<br>  o 3403 Macromolecular and materials chemistry<br>• 40 Engineering<br>  o 4003 Biomedical engineering<br>    » 400302 Biomaterials<br>  o 4004 Chemical engineering<br>  o 4014 Manufacturing engineering<br>    » 401401 Additive manufacturing<br>  o 4016 Materials engineering<br>  o 4018 Nanotechnology<br>    » 401807 Nanomaterials<br>• 51 Physical sciences<br>  o 5104 Condensed matter physics<br>*Note: Closest equivalent ANZSRC 2008 code used for R&D expenditure data (02 Physical sciences, 03 Chemical sciences, and 09 Engineering). |
| **Occupations**<br>*Australian and New Zealand Standard Classification of Occupations (ANZSCO)* | **ANZSCO 2022 and ANZSCO 2013 V1.3**<br>• 2331 Chemical and materials engineers<br>  o 233111 Chemical engineer<br>  o 233112 Materials engineer<br>• 2342 Chemists, and food and wine scientists<br>  o 234211 Chemist |

## What is driving the demand for materials science?

Australia's demand for materials scientists and expertise is growing. Novel materials and expertise in their development and use are needed to:

- build sovereign capability (and decrease close-to-total reliance on international supply chains) to generate new materials underpinning new technologies – in space science, defence, health, semiconductors, quantum and AI servers
- support effective and efficient care for an ageing population by improving health technologies
- tackle climate change and other environmental challenges via greenhouse gas removal methods, hydrogen production and other energy technologies, bushfire resilience, and environmental sensors.

## Will Australia have sufficient capability to meet demand in materials science?

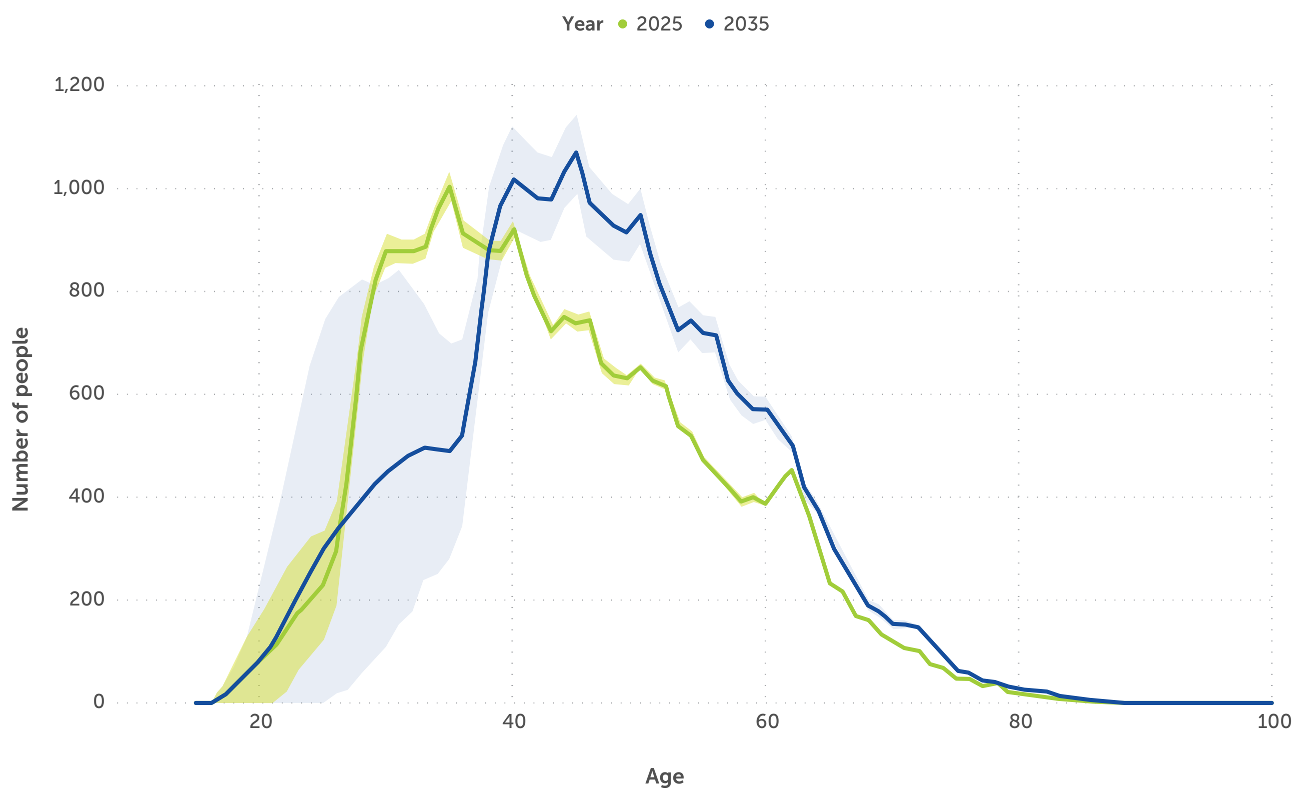
Across materials science capability areas, indicators point to a system under strain.

Enrolments in relevant Year 12 subjects and undergraduate degrees have declined, while participation at the VET level has remained steady. Completions in undergraduate programs have also decreased, with VET and postgraduate completions remaining similar.

There are national shortages of materials engineers, while no current shortages are recorded for chemists.

The workforce in process and resources engineering is projected to be declining, and in the chemical sciences, it is projected to be stationary. These are not signs of a system responding dynamically to evolving national needs, and indicate an existing gap on track to be worsening.

**Figure 13** – Forecasted age distribution of the working population with a university qualification in process and resources engineering in 2025 and 2035. Shaded areas represent 90% prediction intervals.




Funding for research in chemical sciences has decreased, while investment in physical sciences has grown. Research output is mixed, and patent activity is stable or growing.

Taken together, the data show a sector where warning signs are evident.

Read in more detail in Appendix C.

## Technological transformation

New battery developments involve refinements of the current lithium-ion technology, as well as new battery chemistries. Other innovations will include novel ways of charging batteries, such as using piezoelectric materials.

## Demographic change

Climate change will increase the risk of natural disasters and extreme weather events, so our housing must be built to be resilient. Materials science will be needed to build homes that will keep Australians safe during disasters and protect them from extreme temperatures. For example, non-conductive materials in homes can avoid thermal bridges, ensure energy efficiency, and reduce mould risk.

## Climate change, decarbonisation and environment

Environmental sensors monitor the levels of chemical pollutants. Materials such as carbon nanotubes and graphene are being investigated as potential sensing materials for environmental gas sensors.

# WHAT DO SCIENCE CAPABILITIES **MEAN FOR AUSTRALIA'S FUTURE?**

**Australians know that there are forces shaping our future. Capacity to make decisions for ourselves about what to adopt, how and why is critically important.**

Even a basic sense of responsibility to future generations compels us to make the investment, carefully and patiently.

We speak of commercialising the output of our scientists as if it's akin to a light switch – flick it and she'll be right.

For most scientific and technological fields, the average time from initial discovery to a commercially available product is typically in the range of 10–20 years, with highly regulated or complex products (like drugs or advanced materials) taking the longest, and less regulated, incremental, or digital products reaching market much faster. The journey is influenced by regulatory hurdles, required testing, scale-up challenges, and market validation at each stage.

The National Reconstruction Fund seeks to influence the forces shaping the Australian economy. Established by the Australian Government, the fund sets out priority areas to grow industrial capabilities, enhance productivity, and bolster economic security and resilience. We have mapped the eight areas of science capability in highest demand against the fund's priority areas.

They need the support of Australian scientists. To achieve movement, investment in the financing and policy framework that supports science will need to be focused, substantial – and patient.

Investing today, getting our platform right, could mean 10–20 years before the pay-off. But if we do not, we will be importing our knowledge, our smarts, our solutions from overseas at a premium – just as we have done too often.

| NATIONAL RECONSTRUCTION FUND PRIORITY AREA | SCIENCE CAPABILITIES | |
|---|---|---|
| VALUE-ADD IN RESOURCES | GEOSCIENCE<br>MATERIALS SCIENCE | DATA SCIENCE<br>ARTIFICIAL INTELLIGENCE |
| VALUE-ADD IN AGRICULTURE, FORESTRY AND FISHERIES | AGRICULTURAL SCIENCE<br>BIOTECHNOLOGY<br>CLIMATE SCIENCE | DATA SCIENCE<br>ARTIFICIAL INTELLIGENCE |
| TRANSPORT | MATERIALS SCIENCE<br>GEOSCIENCE | DATA SCIENCE<br>ARTIFICIAL INTELLIGENCE |
| MEDICAL SCIENCE | BIOTECHNOLOGY<br>EPIDEMIOLOGY | DATA SCIENCE<br>ARTIFICIAL INTELLIGENCE |
| RENEWABLES AND LOW EMISSION TECHNOLOGIES | CLIMATE SCIENCE<br>MATERIALS SCIENCE | DATA SCIENCE<br>ARTIFICIAL INTELLIGENCE |
| DEFENCE CAPABILITY | MATERIALS SCIENCE<br>BIOTECHNOLOGY<br>GEOSCIENCE | DATA SCIENCE<br>ARTIFICIAL INTELLIGENCE |
| ENABLING CAPABILITIES | BIOTECHNOLOGY<br>MATERIALS SCIENCE<br>GEOSCIENCE | DATA SCIENCE<br>ARTIFICIAL INTELLIGENCE |

***Carl Sagan once said***

*'We live in a society exquisitely dependent on science and technology, in which hardly anyone knows anything about science'.*

# KEY ENABLERS FOR AUSTRALIA'S **SCIENCE CAPABILITY TO 2035**

## Australia faces a rapidly changing global and geopolitical context.

The forces shaping our future – not least our economy – require a science system that is collaborative and connected. Science needs more capability and capacity in a system that is coordinated, coherent, and fit for purpose.

That means genuine alignment between states, territories, portfolios, disciplines and sectors – so that we are not simply funding projects, but building a system. A system that connects capability with need, and investment with impact. One that generates knowledge so that we can confidently face the challenges and opportunities in Australia's future.

Each science capability will require enabling services and facilities. Building capability in the eight high-demand disciplines will be strongly influenced by our ability to nurture science literacy and to fortify national resilience in the face of geopolitical instability.

## Science literacy and education

Carl Sagan once said, *'We live in a society exquisitely dependent on science and technology, in which hardly anyone knows anything about science'*.

**The capability and capacity of Australians to make informed decisions starts with the education system.**

It is imperative that Australia has the expertise available for the decades to come: to respond to the next pandemic, to build and adapt critical technologies, to understand and protect our environment.

Science, technology, engineering and mathematics (STEM) content knowledge and skills are fundamental foundations in our lives and our future. Science literacy (the ability to understand and apply scientific concepts and processes to make informed decisions) is at the heart of almost everything we do and how we advance as a nation, from solving major problems to creating new businesses and jobs we haven't yet imagined.

**STEM school education and science literacy are vital underpinning enablers, supporting community participation and science in Australia by:**

- supporting students to develop and sustain interest, knowledge and skills in STEM-related subjects
- developing a STEM-literate citizenry who are interested enough and know how to find out about the science that shapes their world
- ensuring a robust future science system.

**To support Australia's evolution, STEM-related school education must evolve across several key areas.**

1. STEM capability should be framed as a foundation for active citizenship and societal stewardship, along with other relevant subjects – while acknowledging the broader contribution of STEM-skilled individuals beyond formal science careers.
2. There needs to be stronger support for out-of-field teachers, who often carry the responsibility of delivering STEM content without adequate subject training.

   A 2020 report published by The University of Sydney and Monash University found that 12.5% of Year 10 STEM classes are taught by teachers outside their field of expertise. While this is a concern, it is also the challenge for teachers who might have training in one science but are expected to teach another very different type of science ('near out-of-field' teachers).

   The Australian Council of Deans 2005 report *Who's teaching science* found that less than 50% of teachers teaching senior level geology subjects had studied any geology at a tertiary level.[36] Of the 701 middle-year (Year 9 and 10) teachers who participated in the survey, less than 10% had a major in geology. This lack of teacher experience can result in a 'leak' in the pipeline of students selecting these subjects in senior schooling or at a tertiary level. This in turn affects the availability of related workforces in the future.
3. Sustained investment in teacher capability and professional support is needed to develop the skills required in problem-solving, critical thinking, creativity and digital literacy. Equitable access to high-quality teaching resources – paired with ongoing professional learning – will help ensure consistency in STEM education across the diverse range of contexts. This will form the foundation upon which our future scientifically literate population will be able to make informed decisions.
4. There must also be a shift beyond viewing academic achievement as the sole measure of student success, recognising broader capabilities and diverse pathways. The traditional 'STEM pipeline' model requires rethinking. Framing careers outside the linear STEM trajectory as a skills loss is limiting and outdated. Instead, STEM skills should be recognised as valuable across all sectors and roles.

## Shaping the workforce we will need in 2035, for 2060

Australia's ability to meet its national ambitions depends on the strength and adaptability of its scientific workforce. Yet, from school to career, the pipeline remains rigid, fragile and misaligned with the country's future needs.

One of the most persistent issues is that high school students' university subject choices effectively shape the size and structure of our tertiary teaching and research workforce.

This bottom-up pressure constrains institutional offerings and, over time, narrows the supply of expertise in disciplines critical to national interest, regardless of where demand actually lies.

Domestic enrolments in many science PhD programs are declining, even as demand for scientific capability grows in those same disciplines. Meanwhile, research career pathways remain limited and linear. Mobility between academia, government, and industry is still the exception rather than the norm, limiting the circulation of talent and ideas.

Without deliberate intervention, these patterns reinforce a system that trains for the past, not the future.

To address this, Australia needs a strategic approach to science capability planning – one that spans education, training, research and employment. This means understanding where future skill needs are emerging, how those needs differ across sectors, and where the pinch points are.

It also means embracing the full spectrum of science-relevant skills, including vocational training. As we decarbonise, the need for technicians and electricians will grow. Similarly, the physical infrastructure that supports digital innovation – from supercomputers to sensor networks – requires specialist trades and technical skills.

Flexibility is key. More responsive education pathways, cross-sector mobility programs, and targeted incentives to develop capability in under-supplied areas can help realign workforce supply with strategic need. But these changes must be supported by a long-term view: one that treats people not just as inputs to a system, but as the foundation of national capability.

If Australia wants to be ready for what's next, it needs to invest in the people who will shape it.

## Geopolitical uncertainty and International collaboration

Australia sought to establish itself in research post-1946, when visionaries determined that we had to change as a nation, and went about ensuring we did. The first Australian PhDs were awarded in 1948. Prior to that, the few scientists with formal research training were prepared overseas.

Research became a key function of our university sector – and international collaboration has always been part of it. We draw on expertise and contribute in multiple ways including through arrangements to provide opportunities to citizens of countries in our region. Relationships have been built – personal, professional and national – that endure. Our commitment to the region continues in different forms.

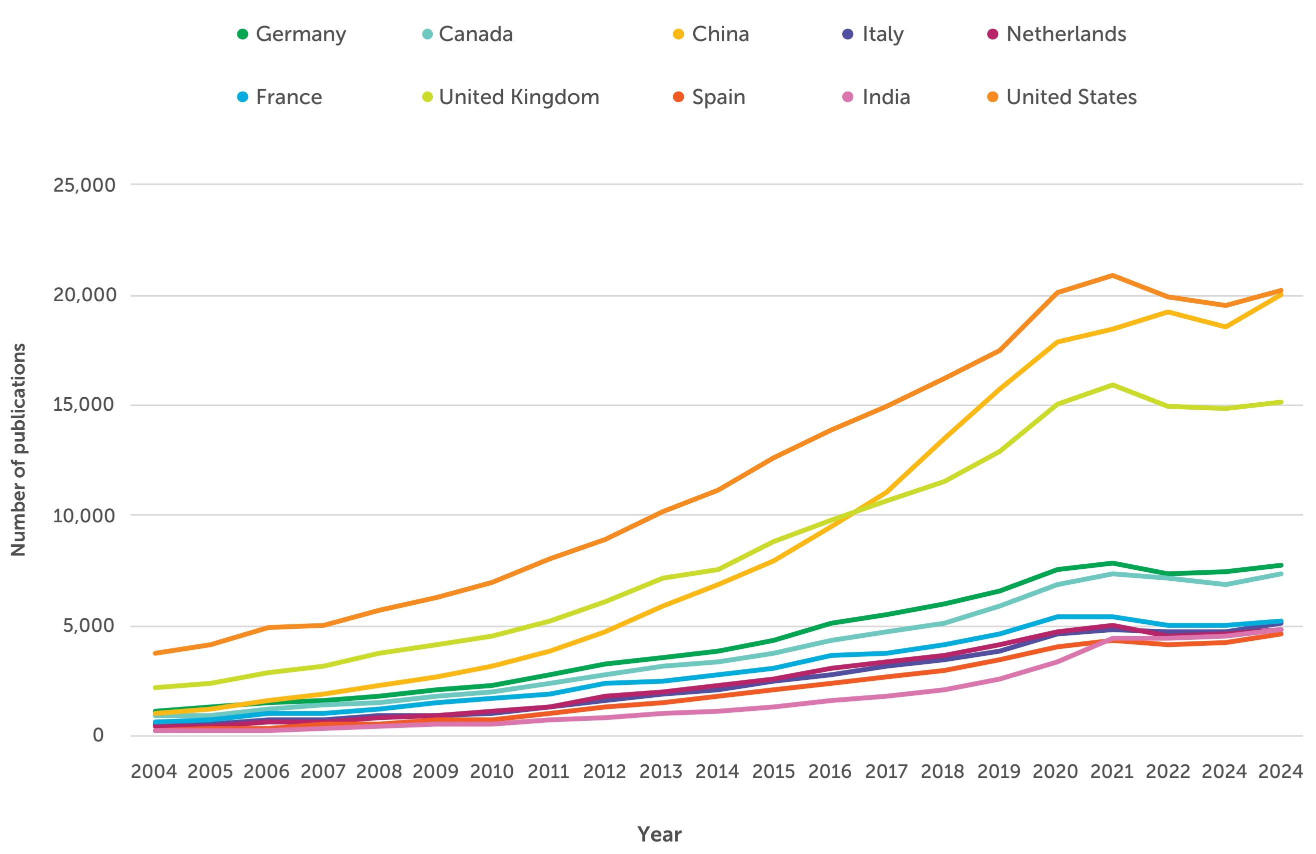
Australia's scientific research has deep ties with the United States, China and the United Kingdom. These three partners dominate our collaborative output, accounting for a significant share of Australia's co-authored scientific research publications and shared infrastructure access.

Yet despite this clear reliance, there is a striking lack of system-level visibility into the nature of these partnerships, including what capabilities they build, what vulnerabilities they expose, and how the science capabilities they support align with Australia's strategic interests.

In today's contested global landscape, understanding the depth and character of these relationships is no longer a luxury, it is a strategic necessity.

Collaborations are not politically neutral. They shape – and are shaped by – foreign policy, national security settings, and shifting geopolitical alliances.

**Figure 14** – Australia's international collaborations outputs in science* (number of publications), 2004–2024. Source: Dimensions AI.




**Includes the following FoR codes: 30 Agricultural, veterinary and food sciences; 31 Biological sciences; 32 Biomedical and clinical sciences; 34 Chemical sciences; 37 Earth sciences; 40 Engineering; 41 Environmental sciences; 42 Health sciences; 46 Information and computing sciences; 49 Mathematical sciences; 51 Physical sciences and 52 Psychology.*

New partnerships are emerging as different nations build their science and technology capabilities.

Building sovereign capability does not mean going it alone. But we need a clear picture of where our strengths lie, where we are overexposed, and where new partnerships might offer both scientific benefit and strategic balance.

These activities provide opportunities to deepen knowledge sharing and facilitate access to research infrastructure, talent and technologies – expanding our domestic science capabilities and ability to navigate complex challenges.

In a world where science is increasingly part of the architecture of statecraft, Australia must be prepared not just to participate, but to shape its future with clarity and purpose.

## How AI is transforming science and the productivity of scientists

By 2035, AI will have transformed how science is conducted, automating routine tasks, accelerating discovery, and enabling new forms of analysis across disciplines. Planning for Australia's future science capability must consider not just *what* science we need, but *how* it will be done, with AI central to driving scientific productivity and innovation.

Over the past decade, artificial intelligence (AI) has rapidly transformed scientific research worldwide, as reflected in the growing volume of research papers on AI and its increasing use across scientific disciplines.[37] AI tools are poised to become essential to most scientific fields in the coming decade.[38]

AI has applications in fundamental, applied, and clinical research, from the generation of new research hypotheses to automated data acquisition and faster data processing.[39] Some of these methods will drive a fundamental shift from traditional research to more data-centric approaches while enhancing efficiency and productivity in scientific research.

Already, AI can predict high-impact research[40] and augment and automate tasks such as literature reviews, data analysis, and bibliometric analyses. In doing so, AI automates research tasks traditionally carried out by scientists, which could yield a better use of scientists' time.[41]

In light of pressing global challenges, it is imperative to expedite scientific discovery. Issues such as increasing antibiotic resistance, climate change, and the emergence of infectious diseases necessitate prompt and effective responses.

For instance, the identification of novel antibiotics has traditionally been a labour-intensive endeavour, often requiring more than 10 years. However, AI is now expediting this process. By analysing datasets encompassing chemical compounds and protein structures, AI facilitates the identification of targets for prospective antibiotic candidates, while also predicting bacterial structures and their potential development of resistance.

AI is anticipated to increase multifactor productivity by 0.5% to 13% over the next decade, presenting significant opportunities for the Australian economy.[42] Investing in AI has the potential to enhance scientific productivity and discovery, as well as its application and integration in society.

A well-structured policy framework is crucial for Australian scientists to successfully navigate the challenges and opportunities AI is presenting. Such a framework should direct strategic investments in infrastructure, establish ethical guidelines, and foster educational programs, enabling scientists to responsibly and effectively benefit from AI's potential.

The absence of explicit guidance on preparing and adapting our science sector presents a significant challenge to Australia. It could potentially jeopardise our sovereign capability and undermine our ability to shape our scientific future independently.

Areas of priority include building Australia's sovereign AI capability by addressing Australia's skills gap, investing in high-performance computing, improving data storage and governance, supporting high-quality research and data generation, and implementing measures to build trust in AI.

If action is taken, it will not only ensure the continued strength and relevance of the Australian science sector, reinforcing Australia's disproportionate contribution to global science, but also solidify our position in the global scientific community as a forward-thinking and adaptable leader.

## Computing and data infrastructure enabling the next generation of science

Building AI capability in Australia starts with access to world-class high-performance computing and data (HPCD) infrastructure. Without next-generation HPCD (supercomputers), Australia will not have the computational backbone required to support AI-enabled science and so undermine science's capacity to maintain sovereign capability in critical areas.

In the 21st century, HPCD, is the cornerstone of global competitiveness, underpinning critical advancements in science, industry and society.

Supercomputers impact Australians' everyday lives. They support accurate weather forecasting, improve agricultural productivity, accelerate drug discovery, and drive the development of new technologies, including AI, to create jobs and fuel economic growth. As datasets grow larger, and simulations become more complex, existing supercomputing systems are no longer adequate.

Australia has no plan for the next generation of supercomputing or to replace the computing infrastructure Australia currently relies on. Australia's HPCD infrastructure is of moderate capacity, oversubscribed and ageing and is no longer sufficient to meet the scientific and societal demands of the 21st century – risking sovereignty and economic competitiveness, limiting rapid responses to emergencies, and exposing the nation to national security risks.

Existing HPCD infrastructure lacks the necessary computational power to support the growing demands of modern science. Data-intensive applications in genomics, climate modelling and precision agriculture require faster, more scalable systems to process massive datasets and run high-resolution simulations.

Many of our international peers, including China, the US and European countries, are either already operating or planning for exascale HPCD capabilities and beyond.

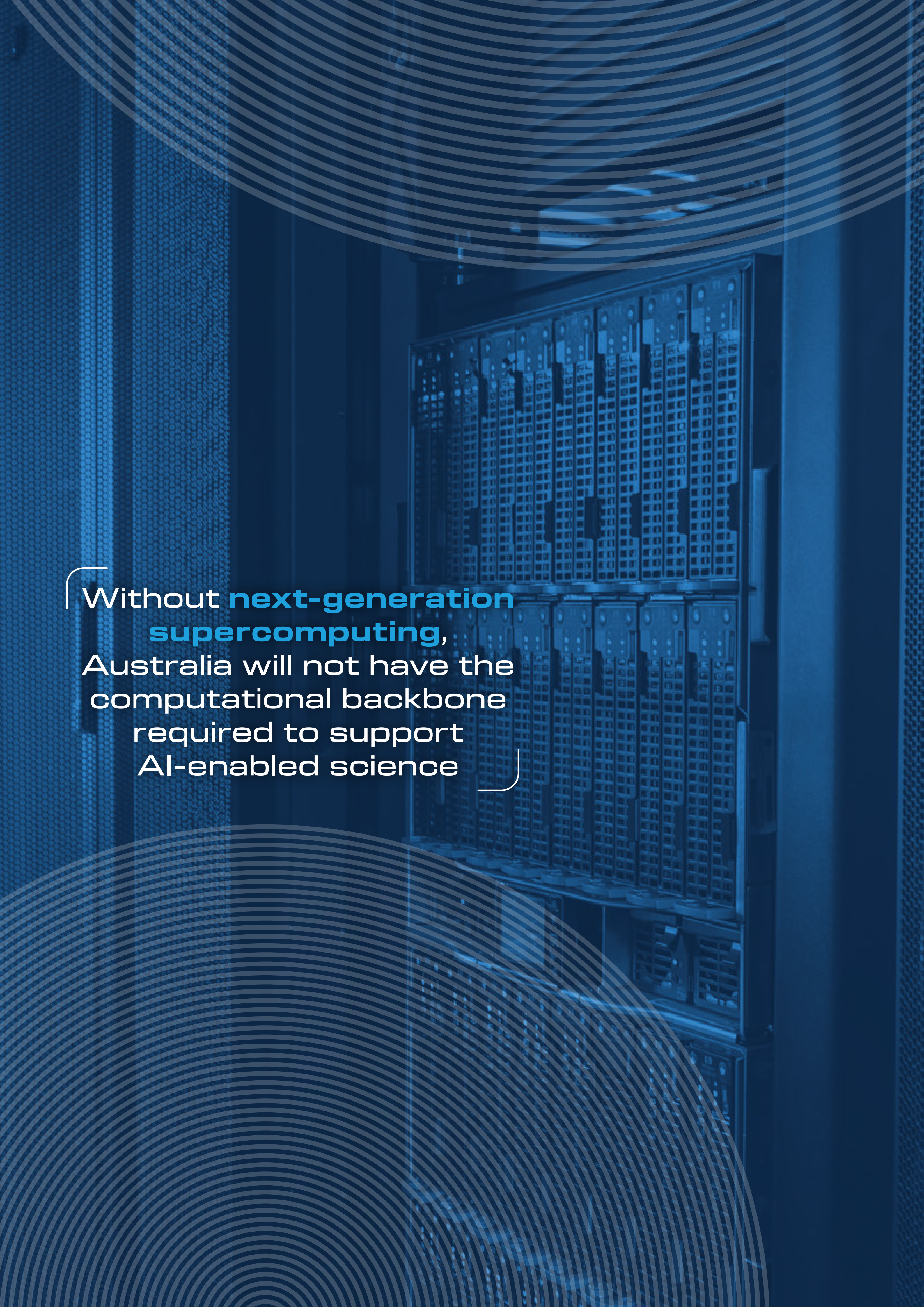
Without a national strategy to acquire and sustain next-generation HPCD for our science sector, Australia will fall behind peer countries. Our sovereignty will be compromised, our ability to innovate and tackle emerging societal challenges will be limited and we will put our future prosperity and security at risk.

#### *LACK OF RELIABLE TELECOMMUNICATIONS INFRASTRUCTURE*

High-quality telecommunications infrastructure is no longer a luxury – it is a baseline requirement for doing science. From operating remote sensing networks and transmitting research data, to participating in international collaborations, connectivity underpins every part of the research process.

It is also essential for delivering services, especially in rural and remote regions where telehealth, environmental monitoring, and distance education rely on stable digital links.


Credit: Jamie Kidston/ANU



Without **next-generation supercomputing**, Australia will not have the computational backbone required to support AI-enabled science

## Many disciplines will need to work together to address challenges

Collaboration is a core part of how humans solve problems, working together enables outcomes no single actor could achieve alone. Global examples, like the successful phase-out of chloroflurocarbons to protect the ozone layer, show how coordinated science and policy efforts can deliver impact at scale.

For Australia, collaboration is not just beneficial, it's essential. Our geographic isolation and relatively small population mean we must engage actively with neighbours and international partners to share knowledge, anticipate regional pressures, and learn from others' experiences as we face our own growth, environmental shifts, and technological acceleration.

### *MULTIDISCIPLINARY APPROACHES*

Strengthening Australia's science system also requires embracing multidisciplinary approaches and systems thinking. This includes drawing on Traditional Knowledges and blending insights from the natural and physical sciences with the humanities and social sciences.

By integrating diverse ways of knowing, we build a more resilient, adaptive and context-aware response to the complex challenges ahead.

Multidisciplinary approaches must be recognised as essential to addressing complex challenges and supported through structural enablers, including fit-for-purpose funding mechanisms through bodies such as the Australian Research Council (ARC) and National Health and Medical Research Council (NHMRC). This will require shifts in how research excellence is defined and rewarded. Adherence to Free, Prior, Informed Consent, and Indigenous Cultural and Intellectual Property principles support this approach in practice.

Meaningful engagement – whether with international partners or First Nations communities – depends on deliberate investment in relationship-building, co-design processes, and culturally appropriate methodologies. This means slowing down where necessary to create enduring, high-impact outcomes.

### *KNOWLEDGE BROKERING*

Knowledge brokering plays a crucial role in linking science with decision-making, going well beyond traditional science communication.

It involves tailoring research to context, ensuring its relevance, and delivering it at the right time to inform policy and practice. These functions – often unseen – act as the connective tissue between the research community, government, and end users. Despite their importance, brokering services remain undervalued and under-resourced. Investing in dedicated platforms and intermediaries to support knowledge brokering could significantly improve the efficiency and impact of research translation.

On a global scale, active participation in trusted international platforms is critical for enabling collaboration while safeguarding Australia's sovereign interests.

Initiatives like Horizon Europe and the Belmont Forum offer transparent, structured models for engageing with international partners. Supporting participation in such platforms allows Australia to access global expertise, contribute to and direct shared priorities, and maintain strategic control over data and capabilities.

# BUILDING OUR SCIENCE CAPABILITY **MUST START NOW**

The world is undergoing a massive structural change where new knowledge must translate into advanced products, processes and services to meet pressing domestic and global challenges.

To create a system that is flexible enough to respond and adapt (bold enough to stop some things, not just start new ones) we need to build in foresighting, feedback and strategic governance. That means moving beyond an expectation of continual expansion to one that values reflection, course correction and measured risk.

A system capable of change must be supported by funding and performance frameworks that reward collaboration, adaptability and long-term impact. Crucially, we need governance structures with the authority and confidence to redirect effort when needed. Not simply to back the next new trendy idea, but to reshape the system in the nation's interest.

But a system cannot adapt to what it cannot see. The current gaps in data and classifications make it difficult to track our science capability or anticipate when it will, or won't, meet national demand.

Building a responsive system requires investing in the infrastructure to understand it so we can shift direction with purpose, not hunch.

A nation that does not understand the science it depends on will one day find that science is not there to depend on.

We must invest in knowledge, in capability, and in capacity. When we support the people who ask the hard questions we do two things: we build the reservoir of talent in our people and we reduce dependence on borrowed research or knowledge. We also build capacity to get answers, even if those answers are inconvenient or discomforting.

There are forces shaping our future, and Australians should know them. They have been developed and argued in the *2023 Intergenerational report*.

While these Intergenerational forces are high level, the National Reconstruction Fund priorities offer a more immediate focus to influence the *forces shaping the economy.*

The capacity to make decisions for ourselves about what to do, what to adopt, how and why is critically important.

### *IT IS NOT THAT SIMPLE*

We speak of the pace of innovation as though it were a universal constant, but the reality is more textured. In pharmaceuticals, for instance, the journey from initial discovery to market approval stretches across 10 to 15 years, sometimes 30 or more in complex fields like gene therapy. That's not sluggishness; it's the result of rigorous checks and balances to ensure safety and efficacy.

In materials science, the so-called '20-year rule' is a telling guidepost. A new compound or material conceived in a lab today may not see commercial application until two decades later. The mining sector mirrors this slow march, held up not by lack of will, but by a complex dance of permitting, environmental assessment, and infrastructure build-out.

Medical devices are another reminder: it takes about 17 years, on average, to translate into actual patient benefit. That's not a failure of science, but a signal of the systems and safeguards we rightly demand when lives are on the line.

If we want policy that truly enables innovation, we must respect these timelines. Science is not a sprint. It's a relay – handing knowledge from lab bench to pilot project to market shelf, with public trust riding alongside at every handover.

Investing today, getting our platform right, could mean 10–20 years before any pay-off. But if we do not, we will be importing back our knowledge, our smarts, our solutions from overseas at a premium – just as we have done too often.

***IT'S TIME TO CHANGE, THIS TIME.***

# APPENDIX A
# FULL METHOD

## Method literature review and consultation

To determine the method, the Academy sought meetings with peak bodies, Learned Academies and Royal Societies, both in Australia and internationally, to investigate what methods had been used to measure science capability. This was paired with a literature review of methods.

This search did not yield any pre-existing method ready to be used. Therefore, the method designed, used and outlined here is a novel approach inspired by other processes.

## Selection of challenges and underpinning challenges

The key challenge areas were selected after our literature review of federal and state government reports. This review of reports revealed many overlapping priorities and descriptions of challenges. However, the longitudinal approach of the *Intergenerational report 2023* and its framing of challenges shaping the economy was most useful to this project, as building science capability is a multidecadal process.

**The five forces of the *Intergenerational report* were initially reframed as four challenges that could have science capability mapped against them:**

- technological transformation
- demographic change
- climate change, decarbonisation and environment
- supply chain resilience.

## Primary mapping of science capabilities

Following this, the Academy shared a survey to map the key areas of science capability that sit under each challenge area. This survey was completed by individuals and organisations, and included an option to nominate experts in those capability areas who could contribute to workshop discussions.

The public consultation was held on the Academy's website and data was collected via Slido.

This survey showed that under the 'supply chain resilience' challenge, it was difficult to inform the science capabilities needed – apart from measuring what had been needed in the past in the face of supply chain disruptions, for example, mRNA capabilities during the COVID-19 pandemic. For this reason, supply chain resilience was removed as one of the challenges and reframed into an 'underpinning' challenge alongside 'science literacy and education' relating to geopolitical instability.

**The three challenges were then finalised as:**

- technological transformation
- demographic change
- climate change, decarbonisation and environment.

The survey helped form the first set of draft Field of Research (FoR) codes for inclusion in this report's analysis. These codes were then revised with input from the advisory panel and the Academy's National Committees for Science.

## Data compilation and visualisation

The Academy compiled data dashboards to present information on the science capability that help respond to these challenges. Data included:

- education and training
- workforce and skills
- activities and outputs (publications, patents, collaborations)
- expenditure and funding
- challenge-specific data (e.g. export/imports, demographic trends).

**The list of data sources can be found in Appendix B.**

## Workshops to define the science capability needed

The Academy conducted a series of workshops with Learned Academy Fellows, National Committee members, and other leading experts to explore the future of these scientific disciplines.

Expert nominations were compiled from the survey results, and through searches of the Academy's Fellowship, committees and Fellowships of the other Learned Academies in Australia. Experts in areas highly relevant to the challenge areas, that were missing from these initial nomination lists, were found from university webpages.

Nominees were examined based on a range of selection criteria:

| SELECTION CRITERIA | |
|---|---|
| **EXPERTISE** (PRIMARY SELECTION CRITERIA) | EXCELLENCE, LEADERSHIP AND SUBJECT MATTER EXPERTISE |
| **DIVERSITY** | GENDER DIVERSITY<br>ABORIGINAL AND TORRES STRAIT ISLANDER REPRESENTATION |
| **CAREER LEVEL** | EARLY AND MID-CAREER RESEARCHERS (EMCRS) |
| **INSTITUTION** | BROAD REPRESENTATION OF INSTITUTIONS – INCLUDING METRO & REGIONAL INSTITUTIONS<br>RANGE OF AUSTRALIAN STATES REPRESENTED |

First, nominees were selected based on the primary selection criteria (expertise and relevance to the challenge). Where nominees shared the same area and level of expertise, further shortlisting was performed based on additional selection criteria such as diversity, career level, geographical location, and institution.

Nominees that best fit these criteria were selected. Other nominees were listed as a back-up for invitation.

For each of three challenges, two workshops were held (six workshops in total). Fifty-six individuals participated across the six workshops, with 10–20 participants per workshop. The workshops were held online and used a combination of small group breakout sessions and full-group discussion to elicit perspectives on the science capabilities Australia needs to respond to the challenges.

Qualitative outputs from the workshops were synthesised to extract key topics and science capabilities for further analysis.

## Further scoping demand for science with users and industry

Following this, the Academy interviewed a range of demand-side stakeholders who are users of science or peak bodies for industry. The analysis of these interviews was used to confirm the key areas of capability growing in demand.

Stakeholder mapping was conducted to identify leaders in organisations who use science, such as policymaker and industry. Top claimants of Australia's R&D Tax Incentive were included. Invitees were selected with consideration given to representing a breadth of sciences and types of organisations.

**Questions were developed using the 'Seven Questions' method published by the UK Futures Toolkit as a guide. The following questions were used:**

1. Imagine it is 2035, what do you see as the likely demand of your organisation for science or STEM (science, technology, engineering and mathematics)?
2. What would be your priorities for an ideal science and innovation system? What would be the signs of success?
3. What is at risk if we don't achieve this vision?
4. In the context of science and scientists in the next 10 years, how do you need culture, organisation, resources, people or policies to change to achieve success?
5. Thinking about where we are today, what can we learn from things that haven't gone well?
6. What decisions need to be made in the near term to achieve the desired long-term outcome?
7. If you had a mandate, without constraints, what would you do?
8. Anything else you'd like to add?

Twenty-one online interviews were conducted. Interview transcripts were manually coded using Nvivo Version 15 to identify themes.

## TOWS analysis

A Threats, Opportunities, Weaknesses and Strengths analysis of Australia's science system was conducted with members of the project team to identify significant risks, weaknesses and opportunities and inform strategic options. This analysis is an extension from a SWOT analysis which takes insights from the SWOT and is used for strategy creation. Insights from the interviews were added to this analysis.

## Forecasting the future population of science disciplines in Australia

In collaboration with Monash Business School, forecasting was conducted to identify shifts in the science workforce in Australia; to help anticipate future demand for science capabilities; and to highlight potential workforce gaps as ageing and retirement reshape the workforce.

The forecasts account for key demographic factors, including mortality, retirement, graduation, and migration. They estimate the number of individuals in each one-year age group who are active in the workforce and hold a bachelor's degree or higher in the narrow fields of education (disciplines) under 01 Natural and physical sciences, 02 Information technology, 03 Engineering and related technologies, and 05 Agriculture and environmental and related studies.

The projections extend over a 20-year period to 2041, with focus on the change in workforce age structure between 2025 and 2035. Based on these projections, each discipline was classified has having an ageing, expansive, declining or uncertain workforce.

## Determining science capabilities and measuring gaps in supply

The top eight science capability areas increasing in demand that Australia would need to meet the challenges were identified by analysing the workshop and interview outputs. The capabilities selected were discussed multiple times across multiple workshops and interviews or were highly mentioned in relation to one challenge.

A set of indicators spanning data education, workforce, research expenditure and research outputs were identified. For each indicator, the most recent 10 years of data at time of analysis was used, if available.

**The capability areas were mapped to the following data classification codes to match them with the most relevant data for each indicator:**

- Australian Curriculum learning areas
- Australian and New Zealand Standard Classification of Occupations (ANZSCO) (2022, 2013 v1.3)
- Australian Standard Classification of Education (ASCED) Field of Education (2001)
- Australian and New Zealand Standard Research Classification (ANZSRC) Field of Research (2020, 2008)

A traffic light table template and rating scale based on trends in each indicator were developed and applied to each capability area. Thresholds for increasing or decreasing trends were identified for each data source.

This data-based visual representation of different aspects of science capability underpinned an accompanying assessment of whether there are gaps in a capability area, the scale of these gaps and where these gaps are emerging.

## Yarns

This project tells a story of Australian science, from the perspective of the Australian Academy of Science. We have used data, evidence-gathering, interviews, discussions, and analysis to ensure that we are telling a *true* story. But it is also a story of aspiration: where do we want Australia to be? And what do we need to get there?

We cannot tell the story we need to tell without including Australian Indigenous perspectives.

Academy Fellows engaged with Indigenous scientists in a series of yarns to gather a range of Aboriginal and Torres Strait Islander perspectives on the future of science. The format was informal and was an exchange of ideas and thoughts. With consent, these ideas have helped to inform and shape this report.

> We cannot tell the story we need to tell **without including** Australian Indigenous perspectives.

# APPENDIX B
# DATA SOURCES

| NAME | SOURCE | PERIOD | THRESHOLD | DESCRIPTION |
|---|---|---|---|---|
| **Year 12 students enrolled in a learning area** | Australian Curriculum, Assessment and Reporting Authority (ACARA)[43] | 2013–2022 | +/- 5% | Enrolments in tertiary-recognised subjects classified under the eight learning areas of the Australian Curriculum. Cross-disciplinary subjects are not recorded under the eight learning areas. Students are only counted once in a learning area, even if they are enrolled in multiple subjects. At the time of analysis, 2022 was the most recent year available. |
| **Year 12 enrolments by field of education** | STEM Equity Monitor[44] | 2013–2022 | +/- 5% | Based on data supplied by the Australian Government Department of Education. Data is a count of enrolments. Every Year 12 student can be counted multiple times for each enrolment. |
| **VET program completions by field of education** | National Centre for Vocational Education Research (NCVER)[15] | 2019–2023 | +/- 10% | The number of VET program completions by narrow field of education. |
| **VET program enrolments by field of education** | NCVER[15] | 2019–2023 | +/- 10% | The number of enrolments in VET programs by narrow field of education. |
| **Combined university completions by field of education** | Universities Australia (supplied on request) | 2013–2022 | +/- 10% | The number of university course completions by detailed field of education. For privacy reasons, student numbers below five are not displayed. |
| **Commencing university students by field of education** | Department of Education (supplied on request) | 2014–2023 | +/- 10% | The number of commencing higher education students by narrow field of education, citizenship status and course level.<br><br>The discipline is assigned by providers based on the subject matter of the majority of a student's units of study.<br><br>For privacy reasons, student numbers below five are not displayed. |
| **University course completions by field of education** | Department of Education (supplied on request) | 2014–2023 | +/- 10% | The number of higher education award course completions by narrow field of education, citizenship status and course level.<br><br>The discipline is assigned by providers based on the subject matter of the majority of a student's units of study.<br><br>For privacy reasons, student numbers below five are not displayed. |

| NAME | SOURCE | PERIOD | THRESHOLD | DESCRIPTION |
|---|---|---|---|---|
| **Shortages by occupation** | Jobs and Skills Australia[45] | 2024 | n/a | A point-in-time assessment of the shortage status of occupations in the Australian labour market. Ratings are determined using multiple data sources including the vacancy fill rate (the number of filled vacancies divided by the number of vacancies) and the Survey of Employers who have Recently Advertised, the Occupation Shortage List Stakeholder Survey, a machine learning model and feedback from government agencies and the Jobs and Skills Council. |
| **Skilled temporary migration** | Department of Home Affairs[46] | 2014–15 to 2023–24 | +/- 10% | Number of temporary skilled visas granted by occupation. |
| **Skilled permanent migration** | Department of Home Affairs[47] | 2014–15 to 2023–24 | +/- 10% | Number of permanent skilled migrants by occupation. |
| **Age structure analysis** | Custom analysis[48] | 2025–2035 | n/a | Forecast of future age structure of science disciplines, novel analysis for this report by Professor Rob J. Hyndman FAA FASSA and Kelly Vanh Nguyen. Projections extend 20 years to 2041, with a focus on workforce in 2035. See Appendix A for additional detail. |
| **Employment projections** | Jobs and Skills Australia[49] | 2024–2034 | +/- 5% from 13.7% | Projections of employment in different occupations based in the current economic and labour market outlook. For comparison, total employment in Australia is projected to grow by 13.7% over this period.<br><br>Jobs and Skills Australia notes that 'like any model these projections are based on assumptions and contain a degree of inherent uncertainty. Therefore, they should be used as indicative of the future trends based on our current knowledge, rather than a precise prediction of the future.' In line with this, we have provided the rounded figures as presented by Jobs and Skills Australia. There may be minor discrepancies between the projected employment figures and percentage change listed. |

| NAME | SOURCE | PERIOD | THRESHOLD | DESCRIPTION |
|---|---|---|---|---|
| **Research and teaching workforce** | STEM Equity Monitor[50] | 2019–2022 | +/- 5% | The composition of the teaching and research workforce as reported by the Department of Education. The data includes staff in teaching and research functions and staff levels A to E only. It does not include research-only as they are not assigned to any field of education. The total workforce is larger than reflected in this data. |
| **Expenditure on R&D** | Australian Bureau of Statistics[51–53] | 2012–2022 | +/- 5% | Intramural expenditure on R&D carried out by the business, higher education, government and private non-profit sectors. Intramural expenditure is expenditure for R&D performed by the sector irrespective of the source of funds. For example, R&D activity performed by a university but funded by government grant would appear in higher education expenditure on R&D. |
| **Research publications** | Dimensions AI | 2015–2024 | +/- 10% | The number of publications with at least one author affiliated with an organisation located in Australia.<br><br>Information is also provided on the proportion of global publications but did not factor into ratings. In most areas, Australia's proportion of publications is declining in relation to global publications. This is likely reflective of increased publications by other countries in this period and may not be reflective of Australia's performance. |
| **Patents** | Dimensions AI | 2015–2024 | +/- 10% | The number of patents where the organisation that has been assigned the patent is located in Australia. Patent data in Dimensions is collated and provided by IFI Claims which aggregates information from various sources. |

# APPENDIX C
# TRAFFIC LIGHT TABLES

# Agricultural science

The data classification codes in scope are listed in the Agricultural science chapter.

## EDUCATION

### Year 12 enrolments 2013–2022

ACARA

- Year 12 students enrolled in a science subject **remained similar** from 113,469 to 116,225 (2.43%).
- The percentage of Year 12 students enrolled in a science subject **remained similar** from 50.60% to 50.50% (-0.20%).
  Note: There was a peak in the number and percentage of students studying science in 2017 at 124,711 students (52.70% of students).

STEM Equity Monitor

- Year 12 enrolments in 0501 Agriculture, environmental and related studies **increased** from 5,012 to 5,310 (5.95%).
- Year 12 enrolments in 0105 Chemical sciences **decreased** from 38,993 to 36,516 (-6.35%).
- Year 12 enrolments in 0109 Biological sciences **increased** from 56,522 to 61,491 (8.79%).

### VET completions 2019–2023

- VET completions in 0501 Agriculture **remained similar** from 5,830 to 6,175 (5.92%).
- VET completions in 0503 Horticulture and viticulture **remained similar** from 6,975 to 6,390 (-8.39%).
  Note: there was a peak at 7,580 in 2021.
- VET completions in 0599 Other agriculture, environmental and related studies **increased** from 250 to 290 (16.00%).
  Note: there was a low at 115 in 2022.

### VET enrolments 2019–2023

- VET enrolments in 0501 Agriculture **remained similar** from 18,785 to 19,770 (5.24%).
- VET enrolments in 0503 Horticulture and viticulture **decreased** from 26,995 to 23,010 (-14.76%).
  Note: there was a peak in enrolments at 34,505 in 2021.
- VET enrolments in 0599 Other agriculture, environmental and related studies **increased** from 1,485 to 2,155 (45.12%).

### University graduates (all course levels and citizenship statuses) 2013–2022

- University graduates in 050100 Agriculture not further defined **remained similar** from 195 to 187 (-4.10%).
  Note: there was a peak of 322 course completions in 2017. From 2018 to 2022 there was a 38.08% **decrease** in university graduates.
- University graduates in 050101 Agricultural science **increased** from 211 to 404 (91.47%).
  Note: there was a peak of 605 in 2019. From 2018 to 2022 there was a 23.05% decrease in university graduates.
- University graduates in 050105 Animal husbandry **increased** from 178 to 209 (17.42%).
- University graduates in 050199 Agriculture not elsewhere classified **increased** from 155 to 256 (65.16%).
- University graduates in 050300 Horticulture and viticulture not further defined **decreased** from 6 to <5.
- University graduates in 050301 Horticulture **remained similar** from 88 to 83 (-5.68%).
- University graduates in 050303 Viticulture **decreased** from 70 to 39 (-44.29%).
- University graduates in 059901 Other agriculture, environmental and related studies not further defined **increased** from <5 to 39.
- University graduates in 059901 Pest and weed control **decreased** from 11 to <5.

## EDUCATION

| | |
|---|---|
| **Undergraduate award course completions** 2014–2023 | • Undergraduate completions in 0501 Agriculture **increased** from 337 to 755 for domestic students (124.04%) and **increased** from 37 to 81 for international students (118.92%).<br>• Undergraduate completions in 0503 Horticulture and viticulture **decreased** from 91 to 43 (-52.75%) for domestic students and **increased** from 10 to 12 for international students (20.00%).<br>Note: there was a peak of international students at 20 in 2016 and a low at <5 in 2022.<br>• Undergraduate completions in 0599 Other agriculture, environmental and related studies **increased** from 167 to 587 (251.50%) for domestic students and **decreased** from 9 to <5 for international students.<br>Note: there was a peak in domestic students at 1,280 in 2022. |
| **Postgraduate award course completions** 2014–2023 | • Postgraduate completions in 0501 Agriculture **remained similar** from 194 to 212 for domestic students (9.28%) and **increased** from 166 to 220 for international students (32.53%).<br>Note: there was a peak of 316 international completions in 2019. From 2019 to 2023 there was a 30.38% **decrease**.<br>• Postgraduate completions in 0503 Horticulture and viticulture **increased** from 64 to 72 (12.50%) for domestic students and **increased** from 12 to 33 for international students (175.00%).<br>• Postgraduate completions in 0599 Other agriculture, environmental and related studies **decreased** from 62 to 36 (-41.94%) for domestic students and **decreased** from 37 to 31 (-16.22%) for international students. |
| **Undergraduate enrolments (commencing)** 2014–2023 | • Undergraduate enrolments in 0501 Agriculture **increased** from 1,096 to 1,293 for domestic students (17.97%) and **increased** from 63 to 205 for international students (225.40%).<br>• Undergraduate enrolments in 0503 Horticulture and Viticulture **decreased** from 150 to 83 (-44.67%) for domestic students and **decreased** from 24 to 16 for international students (-33.33%).<br>• Undergraduate enrolments in 0599 Other agriculture, environmental and related studies **increased** from 262 to 843 (221.76%) for domestic students and **decreased** from 18 to 11 (-38.89%) for international students.<br>Note: there was a peak in undergraduate enrolments at 3,213 in 2020. There was a 73.76% decrease in undergraduate enrolments between 2020 and 2023. |
| **Postgraduate enrolments (commencing)** 2014–2023 | • Postgraduate enrolments in 0501 Agriculture **decreased** from 289 to 220 for domestic students (-23.88%) and **increased** from 275 to 496 for international students (80.36%).<br>Note: There was a peak of 360 domestic students and a low of 147 international students in 2021. From 2021 to 2023 there was a 38.89% **decrease** in enrolments for domestic students, and a 237.42% **increase** in international students.<br>• Postgraduate enrolments in 0503 Horticulture and viticulture **remained similar** from 77 to 82 (6.49%) for domestic students and **increased** from 17 to 66 for international students (288.24%).<br>• Postgraduate enrolments in 0599 Other agriculture, environmental and related studies **decreased** from 99 to 44 (-55.56%) for domestic students and **increased** from 53 to 151 (184.91%) for international students.<br>Note: multiple peaks and troughs. Sharp increase in overseas students between 2022 and 2023 (56 to 151). |

## WORKFORCE

| | |
|---|---|
| **Current**<br>Various time periods | **Occupation shortages (2024)**<br>• The occupation 234114 Agricultural research scientist had national **shortages**.<br><br>**Research and teaching workforce (2019–2022)**<br>• The research and teaching workforce full-time equivalent (FTE) in 05 Agriculture, environmental and related studies **increased** from 507 to 552 (8.88%).<br>• The research and teaching workforce headcount in 05 Agriculture, environmental and related studies **increased** from 532 to 581 (9.21%).<br><br>**Skilled temporary migration (2014–15 to 2023–2024)**<br>• Skilled temporary migration in 234112 Agricultural scientist **increased** from 26 to 30 (15.38%).<br><br>**Skilled permanent migration (2014–15 to 2023–2024)**<br>• Skilled permanent migration in 234112 Agricultural scientist **decreased** from 133 to 56 (-57.89%). |
| **Projected**<br>Various time periods | **Age structure analysis (2025–2035)**<br>• 0501 Agriculture is projected to have an **expansive workforce**.<br><br>**Employment projections (2024–2034)**<br>• Employment of 2341 Agricultural and forestry scientists is projected to **increase** from 8,800 to 10,100 (15.4%). This is **similar to** total projected employment growth (13.7%). |

## FUNDING

| | |
|---|---|
| **R&D expenditure**<br>2012–2022 | • Expenditure on R&D in agricultural, veterinary and food sciences by business **increased** from $572 million* to $1,534 million (168.20%).<br>• Expenditure on R&D in agricultural, veterinary and food sciences by government **decreased** from $870 million* to $636 million (-26.98%).<br>• Expenditure on R&D in agricultural, veterinary and food sciences by higher education **increased** from $494 million* to $648 million (31.10%).<br>• Expenditure on R&D in agricultural, veterinary and food sciences by private non-profit organisations **increased** from $13 million* to $29 million (126.92%).<br><br>*normalised to June 2022 Consumer Price Index. |

## RESEARCH OUTPUT

**Publications 2015–2024**

**3001 Agricultural biotechnology**

- Australian research publications in 3001 Agricultural biotechnology **increased** from 133 to 176 (32.33%).
- Australian research publications as a proportion of global publications in 3001 Agricultural biotechnology **decreased** from 2.12% to 1.58% (-25.11%).
- The top three international collaborators in 3001 Agricultural biotechnology are China, the US and India.

**3002 Agriculture, land and farm management**

- Australian research publications in 3002 Agriculture, land and farm management **increased** from 394 to 504 (32.33%).
- Australian research publications as a proportion of global publications in 3002 Agriculture, land and farm management **decreased** from 4.09% to 2.03% (-50.44%).
- The top three international collaborators in 3002 Agriculture, land and farm management are China, the US and India.

**3003 Animal production**

- Australian research publications in 3003 Animal production **increased** from 428 to 571 (33.41%).
- Australian research publications as a proportion of global publications in 3003 Animal production **decreased** from 3.27% to 2.05% (-37.50%).
- The top three international collaborators in 3003 Animal Production are the US, the UK and China.

**3004 Crop and pasture production**

- Australian research publications in 3004 Crop and pasture production **increased** from 735 to 1,003 (36.46%).
- Australian research publications as a proportion of global publications in 3004 Crop and pasture production **decreased** from 3.59% to 1.74% (-51.50%).
- The top three international collaborators in 3004 Crop and pasture production are China, the US and India.

**3008 Horticultural production**

- Australian research publications in 3008 Horticultural production increased from 227 to 335 (47.58%).
- Australian research publications as a proportion of global publications in 3008 Horticultural production decreased from 2.03% to 1.38% (-32.27%).
- The top three international collaborators in 3008 Horticultural production are China, the US and India.

**3099 Other agricultural, veterinary and food sciences**

- Data not available.

**Patents 2015–2024**

- Australian patents in 3001 Agricultural biotechnology **increased** from 60 to 86 (43.33%).
- There were 10 or fewer Australian patents in 3002 Agriculture, land and farm management each year, with an annual average of 5.1 Australian patents.
- Australian patents in 3003 Animal production **remained similar** from 59 to 61 (3.39%).
  Note: there was a peak in Australian patents in 3003 Animal production at 95 in 2021.
- Australian patents in 3004 Crop and pasture production **decreased** from 112 to 99 (-11.61%).
  Note: there was a peak in Australian patents in 3004 Crop and pasture production at 135 in 2022.
- Australian patents in 3008 Horticultural production **decreased** from 71 to 48 (-32.39%).
- No available data for 3099 Other agricultural, veterinary and food sciences.

## Artificial intelligence

The data classification codes in scope are listed in the Artificial intelligence chapter.

### EDUCATION

**Year 12 enrolments**
2013–2022

ACARA

- Year 12 students enrolled in a mathematics subject **remained similar** from 162,367 to 156,253 (-3.77%).
- The percentage of Year 12 students enrolled in a mathematics subject **decreased** from 72.4% to 67.9% (-6.22%).
- Year 12 students enrolled in a technology subject **decreased** from 79,382 to 64,728 (-18.46%).
- The percentage of Year 12 students enrolled in a technology subject **decreased** from 35.40% to 28.10% (-20.62%).

STEM Equity Monitor

- Year 12 enrolments in 02 Information technology **decreased** from 40,339 to 30,641 (-24.04%).
- Year 12 enrolments in 0101 Mathematical sciences **remained similar** from 191,131 to 187,777 (-1.75%). Note: There have been larger decreases for intermediate (-6.72%) and higher (-8.62%) mathematics.
- Year 12 enrolments in 0104 Physics and astronomy have **decreased** from 30,686 to 25,984 (-15.32%)

**VET completions**
2019–2023

- VET completions in 0201 Computer science **decreased** from 3,055 to 215 (-92.96%).
- VET completions in 0203 Information systems **decreased** from 15,815 to 11,665 (-26.24%).

**VET enrolments**
2019–2023

- VET enrolments in 0201 Computer science **decreased** from 9,420 to 390 (-95.86%).
- VET enrolments in 0203 Information systems **increased** from 48,750 to 55,220 (13.27%).

**University graduates (all course levels and citizenship statuses)**
2013–2022

- University graduates in 020119 Artificial intelligence **increased** from 17 to 802 (4,617.65%). Note: there was a peak of 1,139 graduates in 2021. From 2021 to 2022 there was a 29.59% **decrease**.
- University graduates in 020307 Decision support systems **increased** from <5 to 99.

**Undergraduate award course completions**
2014–2023

- Undergraduate completions in 0201 Computer science **increased** from 1,038 to 2,716 for domestic students (161.66%) and **increased** from 1,087 to 3,671 for international students (237.72%).
- Undergraduate completions in 0203 Information systems **remained similar** from 708 to 766 for domestic students (8.19%) and **increased** from 816 to 1,424 for international students (74.51%).

**Postgraduate award course completions**
2014–2023

- Postgraduate completions in 0201 Computer science **increased** from 412 to 1,021 for domestic students (147.82%) and **increased** from 802 to 2,069 for international students (157.98%). Note: There was a peak of 1,350 domestic students and of 2,558 international students in 2021. From 2021 to 2023 there was a 24.37% decrease in completions for domestic students, and a 19.12% **decrease** in international students.
- Postgraduate completions in 0203 Information systems **remained similar** from 511 to 533 for domestic students (4.31%) and **increased** from 1,394 to 2,487 for international students (78.41%). Note: There was a peak of 4,171 for international students in 2020. From 2020 to 2023 there was a 40.37% **decrease** in international students.

## EDUCATION

| | |
|---|---|
| **Undergraduate enrolments (commencing)** 2014–2023 | • Undergraduate enrolments in 0201 Computer science **increased** from 2,674 to 7,542 for domestic students (182.05%) and **increased** from 1,348 to 9,741 for international students (622.63%).<br>• Undergraduate enrolments in 0203 Information systems **decreased** from 1,935 to 1,373 for domestic students (-29.04%) and **increased** from 1,581 to 3,366 for international students (112.90%). |
| **Postgraduate enrolments (commencing)** 2014–2023 | • Postgraduate enrolments in 0201 Computer science **increased** from 540 to 1,456 for domestic students (169.63%) and **increased** from 1,165 to 6,535 for international students (460.94%).<br>Note: Between 2020 and 2023 domestic enrolments **decreased** from 2,551 to 1,456 (-42.92%).<br>• Postgraduate enrolments in 0203 Information systems **decreased** from 800 to 625 for domestic students (-21.88%) and **increased** from 2,843 to 7,060 for international students (148.33%).<br>Note: there was a high of 1,218 domestic enrolments in 2020. From 2020 to 2023 there was a 48.69% **decrease** in domestic enrolments. There was a low of 2,680 international enrolments in 2021. From 2021 to 2023 there was a 163.43% **increase** in international enrolments. |

## WORKFORCE

| | |
|---|---|
| **Current** Various time periods | **Occupation shortages (2024)**<br>• No direct ANZSCO match.<br>**Research and teaching workforce (2019–2022)**<br>• The research and teaching workforce FTE in 02 Information technology **increased** from 1,089 to 1,302 (19.56%).<br>• The research and teaching workforce headcount in 02 Information technology **increased** from 1,162 to 1,353 (16.44%).<br>**Skilled temporary migration (2014–15 to 2023–2024)**<br>• No direct ANZSCO match.<br>**Skilled permanent migration (2014–15 to 2023–2024)**<br>• No direct ANZSCO match.<br>**Tech Council of Australia (2014–2023)**[54]<br>• Employment in the AI workforce has **increased** from 800 to 33,000 (4025.00%).<br>Note: The Tech Council of Australia used CSIRO data to estimate the 2014 figures, and LinkedIn data to estimate the 2023 figures. |
| **Projected** Various time periods | **Age structure analysis (2025–2035)**<br>• 0201 Computer science is projected to have an **expansive workforce**.<br>• 0203 Information systems is projected to have an **uncertain workforce**.<br>Note: this uncertainty is due to extremely large prediction intervals due to low current workforce numbers but high graduate inflows.<br>**Employment projections (2024–2034)**<br>• No direct ANZSCO match.<br>**Tech Council of Australia (2023–2030)**[54]<br>• Employment of the AI workforce is projected to **increase** from 33,000 to 200,000 (506.06%).<br>Note: The report states that: 'While we forecast fast growth in supply across these occupations, they're unlikely to grow as fast as demand. This will result in shortages.' |

## FUNDING

**R&D expenditure**
2012–2022

- Expenditure on R&D in information and computing sciences by business **increased** from $6,903 million* to $7,927 million (14.83%).
- Expenditure on R&D in information and computing sciences by government **increased** from $319 million* to $442 million (38.87%).
- Expenditure on R&D in information and computing sciences by higher education **increased** from $416 million* to $631 million (51.69%).
- Expenditure on R&D in information and computing sciences by private non-profit organisations **increased** from $9 million* to $30 million (244.45%).

*normalised to June 2022 Consumer Price Index.

## RESEARCH OUTPUT

**Publications**
2015–2024

**4602 Artificial intelligence**

- Australian research publications in 4602 Artificial intelligence **increased** from 866 to 1,356 (56.58%).
- Australian research publications as a proportion of global publications in 4602 Artificial Intelligence **decreased** from 2.46% to 1.54% (-37.18%).
- The top three international collaborators in 4602 Artificial intelligence are China, the US and the UK.

**4611 Machine learning**

- Australian research publications in 4611 Machine learning **increased** from 545 to 2,590 (375.23%).
- Australian research publications as a proportion of global publications in 4611 Machine learning **decreased** from 2.96% to 1.83% (-38.16%).
- The top three international collaborators in 4611 Machine learning are China, the US and the UK.

**4603 Computer vision and multimedia computation**

- Australian research publications in 4603 Computer vision and multimedia computation **increased** from 928 to 1,111 (19.72%).
- Australian research publications as a proportion of global publications in 4603 Computer vision and multimedia computation **decreased** from 2.37% to 1.51% (-36.34%).
- The top three international collaborators in 4603 Computer vision and multimedia computation are China, the US and the UK.

**4605 Data management and data science**

- Australian research publications in 4605 Data management and data science **increased** from 1,612 to 2,689 (66.81%).
- Australian research publications as a proportion of global publications in 4605 Data management and data science **decreased** from 2.40% to 1.47% (-38.68%).
- The top three international collaborators in 4605 Data management and data science are China, the US and the UK.

**Patents**
2014–2023

- Australian patents in 4602 Artificial intelligence **increased** from 23 to 46 (100.00%).
  Note: There was a peak of 53 patents in 2020.
- Australian patents in 4611 Machine learning **increased** from 8 to 73 (812.50%).
- Australian patents in 4603 Computer vision and multimedia computation **increased** from 138 to 215 (55.80%).
- Australian patents in 4605 Data management and data science **increased** from 337 to 602 (78.64%).

## Biotechnology

The data classification codes in scope are listed in the Biotechnology chapter.

| EDUCATION | |
|---|---|
| **Year 12 enrolments** 2013–2022 | ACARA<br>• Year 12 students studying science **remained similar** from 113,469 to 116,225 (2.43%).<br>• The percentage of Year 12 students enrolled in a science subject **remained similar** from 50.60% to 50.50% (-0.20%).<br>• Year 12 students studying technology **decreased** from 79,382 to 64,728 (-18.46%).<br>• The percentage of Year 12 students enrolled in a technology subject **decreased** from 35.40% to 28.10% (-20.62%).<br>STEM Equity Monitor<br>• Year 12 enrolments in 0199 Other natural and physical sciences (includes 019905 Food science and biotechnology) **decreased** from 17,266 to 13,706 (-20.62%).<br>• Year 12 enrolments in 0105 Chemical sciences **decreased** from 38,993 to 36,516 (-6.35%).<br>• Year 12 enrolments in 0109 Biological sciences **increased** from 56,522 to 61,491 (8.79%). |
| **VET completions** 2019–2023 | • VET completions in 0199 Other natural and physical sciences **increased** from 5,910 to 10,325 (74.70%). |
| **VET enrolments** 2019–2023 | • VET enrolments in 0199 Other natural and physical sciences **increased** from 14,135 to 19,555 (38.34%). |
| **University graduates (all course levels and citizenship statuses)** 2013–2022 | • University graduates in 019905 Food science and biotechnology **increased** from 744 to 948 (27.42%).<br>Note: there was a peak of 1,151 graduates in 2021. From 2021 to 2022 there was a 17.64% **decrease.** |
| **Undergraduate award course completions** 2014–2023 | • Undergraduate completions in 0199 Other natural and physical sciences remained similar from 6,929 to 7,466 for domestic students (7.75%) and **increased** from 1,198 to 1,586 for international students (32.39%). |
| **Postgraduate award course completions** 2014–2023 | • Postgraduate completions in 0199 Other natural and physical sciences **increased** from 969 to 1,273 for domestic students (31.37%) and **increased** from 692 to 1,233 for international students (78.18%).<br>Note: there was a peak of 1,433 overseas completions in 2021. From 2021 to 2023 there was a 13.96% **decrease**. |

| | |
|---|---|
| **Undergraduate enrolments (commencing)** 2014–2023 | • Undergraduate enrolments in 0199 Other natural and physical sciences **remained similar** from 13,271 to 13,248 for domestic students (-0.17%) and increased from 1,494 to 3,012 for international students (101.61%).<br>Note: there was a peak of 15,807 domestic enrolments in 2021. From 2021 to 2023 there was a 16.19% **decrease**. |
| **Postgraduate enrolments (commencing)** 2014–2023 | • Postgraduate enrolments in 0199 Other natural and physical sciences **remained similar** from 1,336 to 1,420 for domestic students (6.29%) and **increased** from 1,088 to 2,652 for international students (143.75%).<br>Note: there was a peak of 1,837 domestic enrolments in 2020. From 2020 to 2023 there was a 22.70% **decrease**. |
| **WORKFORCE** | |
| **Current** Various time periods | Occupation shortages (2024)<br>• The occupation 234514 Biotechnologists had no shortages.<br>Research and teaching workforce (2019–2022)<br>• The research and teaching workforce FTE in 01 Natural and physical sciences **decreased** from 3,651 to 3,433 (-5.97%).<br>• The research and teaching workforce headcount in 01 Natural and physical sciences **remained similar** from 3,897 to 3,923 (0.67%).<br>Skilled temporary migration (2014–15 to 2023–2024)<br>• Skilled temporary migration in 234514 Biotechnologist **decreased** from 22 to 12 (-45.45%).<br>Skilled permanent migration (2014–15 to 2023–2024)<br>• Skilled permanent migration in 234514 Biotechnologist **increased** from 23 to 37 (60.87%). |
| **Projected** Various time periods | Age structure analysis (2025–2035)<br>• 0199 Other Natural and Physical Sciences is projected to have an expansive workforce.<br>Employment projections (2024–2034)<br>• Employment of 2345 Life scientists is projected to **increase** from 10,400 to 12,200 (17.8%). This is similar to total projected employment growth (13.7%). |
| **FUNDING** | |
| **R&D expenditure** 2012–2022 | • There were significant changes to the classification of biotechnology field of research subcodes. |

## RESEARCH OUTPUT

| | |
|---|---|
| **Publications** 2015–2024 | **3001 Agricultural biotechnology**<br>• Australian research publications in 3001 Agricultural biotechnology **increased** from 133 to 176 (32.33%).<br>• Australian research publications as a proportion of global publications in 3001 Agricultural biotechnology **decreased** from 2.12% to 1.58% (-25.11%).<br>• The top three international collaborators in 3001 Agricultural Biotechnology are China, the US and India.<br>**3106 Industrial biotechnology**<br>• Australian research publications in 3106 Industrial biotechnology **increased** from 277 to 427 (54.15%).<br>• Australian research publications as a proportion of global publications in 3106 Industrial biotechnology **decreased** from 1.91% to 1.45% (-24.02%).<br>• The top three international collaborators in 3106 Industrial biotechnology are China, India and the US.<br>**3206 Medical biotechnology**<br>• Australian research publications in 3206 Medical biotechnology **increased** from 478 to 697 (45.82%).<br>• Australian research publications as a proportion of global publications in 3206 Medical biotechnology **decreased** from 2.07% to 1.55% (-25.04%).<br>• The top three international collaborators in 3206 Medical biotechnology are the US, China and India.<br>**4103 Environmental Biotechnology**<br>• Australian research publications in 4103 Environmental biotechnology **increased** from 58 to 79 (36.21%).<br>• Australian research publications as a proportion of global publications in 4103 Environmental biotechnology **decreased** from 1.60% to 1.08% (-32.47%).<br>• The top three international collaborators in 4103 Environmental biotechnology are China, India and the US. |
| **Patents** 2015–2024 | • Australian patents in 3001 Agricultural biotechnology **increased** from 60 to 86 (43.33%).<br>• Australian patents in 3206 Medical biotechnology **increased** from 109 to 120 (10.09%).<br>• Australian patents in 3106 Industrial biotechnology **remained similar** from 69 to 66 (-4.35%).<br>• Australian patents in 4103 Environmental biotechnology **increased** from 10 to 13 (30.00%). Note: there was a peak of 26 in 2021. |

## Climate science

The data classification codes in scope are listed in the Climate science chapter.

| EDUCATION | |
|---|---|
| **Year 12 enrolments** 2013–2022 | ACARA<br>• Year 12 students studying science **remained similar** from 113,469 to 116,225 (2.43%).<br>• The percentage of Year 12 students enrolled in a science subject **remained similar** from 50.60% to 50.50% (-0.20%).<br>• Year 12 students enrolled in a mathematics subject **remained similar** from 162,367 to 156,253 (-3.77%).<br>• The percentage of Year 12 students enrolled in a mathematics subject **decreased** from 72.40% to 67.90% (-6.22%).<br>STEM Equity Monitor<br>• Year 12 enrolments in 0107 Earth sciences have **increased** from 3,109 to 4,444 (42.94%). Note: 0107 Earth sciences had the lowest number of Year 12 enrolments compared to other science fields in 2022.<br>• Year 12 enrolments in 0101 Mathematical sciences **remained similar** from 191,131 to 187,777 (-1.75%). Note: There have been **decreases** for intermediate (-6.72%) and higher (-8.62%) mathematics.<br>• Year 12 enrolments in 0104 Physics and astronomy have **decreased** from 30,686 to 25,984 (-15.32%)<br>• Year 12 enrolments in 0105 Chemical sciences **decreased** from 38,993 to 36,516 (-6.35%).<br>• Year 12 enrolments in 0109 Biological sciences **increased** from 56,522 to 61,491 (8.79%).<br>• Year 12 enrolments in 02 Information technology **decreased** from 40,339 to 30,641 (-24.04%). |
| **VET completions** 2019–2023 | • There was no data available on 0107 Earth sciences. |
| **VET enrolments** 2019–2023 | • VET enrolments in 0107 Earth sciences **decreased** from 5 to 0. There were no students recorded between 2021 and 2023. |
| **University graduates (all course levels and citizenship statuses)** 2013–2022 | • University graduates in 010701 Atmospheric sciences **remained similar** from 39 to 37 (-5.13%).<br>• University graduates in 010709 Soil science **increased** from 13 to 39 (200.00%).<br>• University graduates in 010713 Oceanography **increased** from 8 to 13 (62.50%). Note: there was a peak at 27 in 2019. |
| **Undergraduate award course completions** 2014–2023 | • Undergraduate completions in 0107 Earth sciences **decreased** from 264 to 103 for domestic students (-60.98%) and **decreased** from 35 to 19 for international students (-45.71%). |

| EDUCATION | |
|---|---|
| **Postgraduate award course completions** 2014–2023 | • Postgraduate completions in 0107 Earth sciences **decreased** from 264 to 197 for domestic students (-25.38%) and remained similar from 132 to 131 for international students (-0.76%). |
| **Undergraduate enrolments (commencing)** 2014–2023 | • Undergraduate enrolments in 0107 Earth sciences **decreased** from 358 to 234 for domestic students (-34.64%) and **decreased** from 75 to 26 for international students (-65.33%).<br>Note: there was a low of 105 domestic enrolments in 2017. From 2017 to 2023 there was a 122.86% increase. |
| **Postgraduate enrolments (commencing)** 2014–2023 | • Postgraduate enrolments in 0107 Earth sciences **decreased** from 355 to 299 for domestic students (-15.77%) and **increased** from 193 to 238 for international students (23.32%).<br>Note: there was a low of 95 international enrolments in 2021. From 2021 to 2023 there was a 150.53% **increase**. |

| WORKFORCE | |
|---|---|
| **Current** Various time periods | **Occupation shortages (2024)**<br>• No direct occupation match.<br>**Research and teaching workforce (2019–2022)**<br>• The research and teaching workforce FTE in 01 Natural and physical sciences **decreased** from 3,651 to 3,433 (-5.97%).<br>• The research and teaching workforce headcount in 01 Natural and physical sciences **remained similar** from 3,897 to 3,923 (0.67%).<br>**Skilled temporary migration (2014–15 to 2023–2024)**<br>• No direct ANZSCO match<br>**Skilled permanent migration (2014–15 to 2023–2024)**<br>• No direct ANZSCO match<br>***Australian climate science capability review* (2017–2021)**[55]<br>• This review recommended that employment of climate scientists should **increase** from 419 to 496 (18.38%).<br>Note: This was needed to bring Australia to an adequate level of climate capability. |
| **Projected** Various time periods | **Age structure analysis (2025–2035)**<br>• 0107 Earth sciences is projected to have an **ageing workforce**.<br>**Employment projections (2024–2034)**<br>• No direct ANZSCO match. |

## FUNDING

**R&D expenditure 2012–2022**

Earth sciences

- Expenditure on R&D in Earth sciences by business **remained similar** from $154 million* to $151 million (-2.05%).
- Expenditure on R&D in Earth sciences by government **remained similar** from $298 million* to $283 million (-4.94%).
- Expenditure on R&D in Earth sciences by higher education **remained similar** from $362 million* to $350 million (-3.40%).
- Data not available for private non-profit organisations.

Environment

- Expenditure on R&D in environmental sciences by business **decreased** from $353 million* to $288 million (-18.31%).
- Expenditure on R&D in environmental sciences by government **remained similar** from $404 million* to $410 million (1.29%).
- Expenditure on R&D in environmental sciences by higher education **increased** from $429 million* to $531 million (23.55%).
- Expenditure on R&D in environmental sciences by private non-profit organisations **decreased** from $18 million* to $4 million (-76.66%).
  *normalised to June 2022 Consumer Price Index.

## RESEARCH OUTPUT

**Publications 2015–2024**

3702 Climate change science

- Australian research publications in 3702 Climate change science **increased** from 257 to 295 (14.79%).
- Australian research publications as a proportion of global publications in 3702 Climate change sciencee **decreased** from 4.88% to 3.64% (-25.52%).
- The top three international collaborators in 3702 Climate change science are the US, China and the UK.

3701 Atmospheric sciences

- Australian research publications in 3701 Atmospheric sciences **increased** from 762 to 864 (13.39%).
- Australian research publications as a proportion of global publications in 3701 Atmospheric sciences **decreased** from 3.47% to 2.25% (-35.07%).
- The top three international collaborators in 3701 Atmospheric sciences are the US, China and the UK.

3708 Oceanography

- Australian research publications in 3708 Oceanography remained **similar** from 547 to 540 (-1.28%).
- Australian research publications as a proportion of global publications in 3708 Oceanography **decreased** from 6.18% to 4.02% (-34.95%).
- The top three international collaborators in 3708 Oceanography are the US, the UK and China.

3799 Other Earth sciences

- Data not available.

4101 Climate change impacts and adaptation

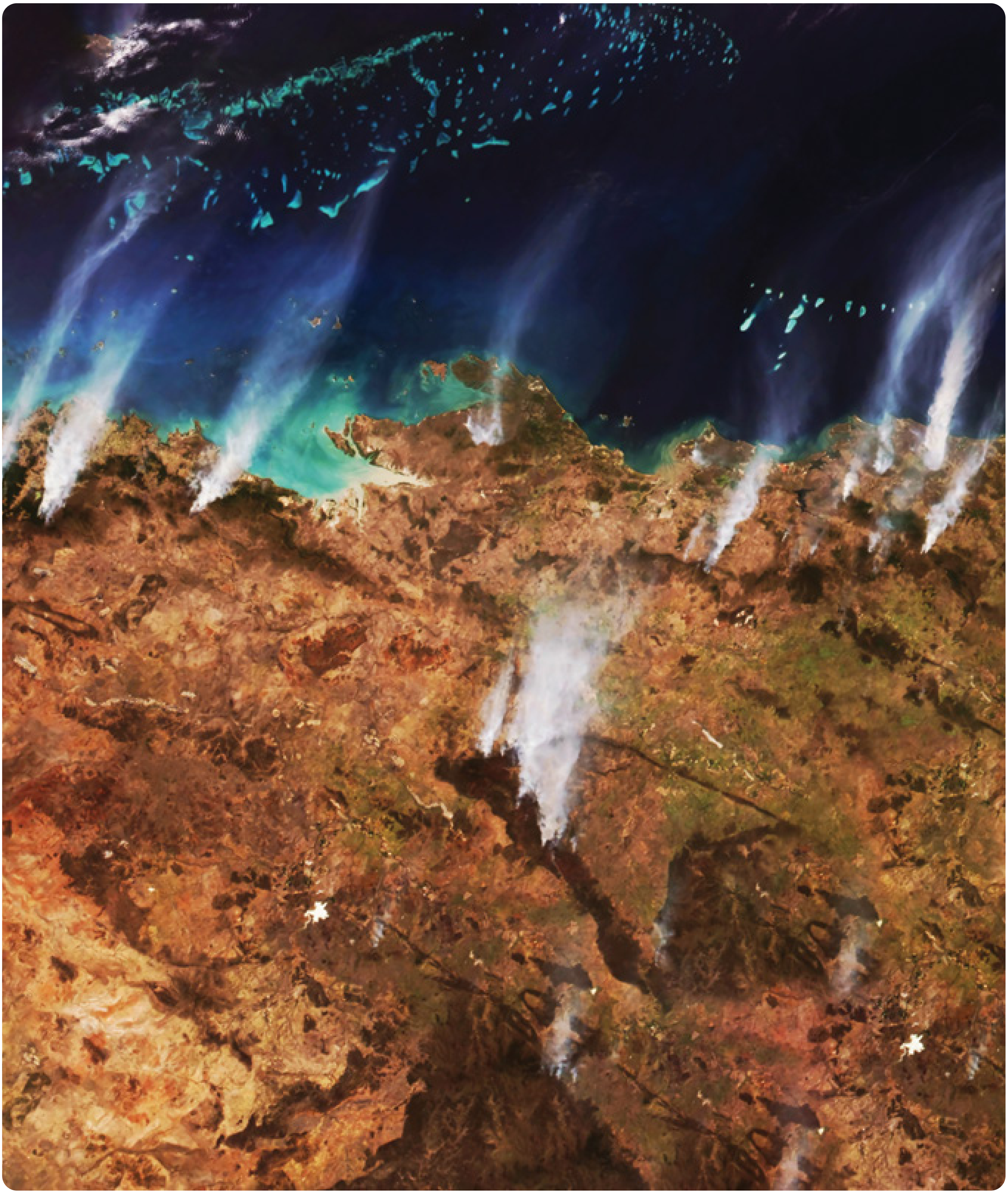
- Australian research publications in 4101 Climate change impacts and adaptation **increased** from 1,227 to 1,740 (41.81%).
- Australian research publications as a proportion of global publications in 4101 Climate change impacts and adaptation **decreased** from 27.22% to 14.01% (-48.52%).
- The top three international collaborators in 4101 Climate change impacts and adaptation are the US, the UK and China.

4106 Soil sciences

- Australian research publications in 4106 Soil sciences **increased** from 246 to 284 (15.45%).
- Australian research publications as a proportion of global publications in 4106 Soil sciences **decreased** from 3.82% to 2.25% (-41.29%).
- The top three international collaborators in 4106 Soil sciences are China, the US and the UK.

**Patents**
2015–2024

- There were 2 Australian patents for 3702 Climate change science.
- Australian patents in 3701 Atmospheric sciences **decreased** from 39 to 18 (-53.85%).
- Australian patents in 4101 Climate change impacts and adaptation **decreased** from 6 to 2 (-66.67%).
- Australian patents in 4106 Soil sciences **increased** from 21 to 37 (76.19%).
- There were 8 or fewer patents Australian patents in 3708 Oceanography each year, with an annual average of 3.1 Australian patents.
- No available data for 3799 Other Earth sciences.



## Data science

The data classification codes in scope are listed in the Data science chapter.

| EDUCATION | |
|---|---|
| **Year 12 enrolments** 2013–2022 | ACARA<br>• Year 12 students enrolled in a mathematics subject **remained similar** from 162,367 to 156,253 (-3.77%).<br>• The percentage of Year 12 students enrolled in a mathematics subject **decreased** from 72.40% to 67.90% (-6.22%).<br>• Year 12 students enrolled in a technology subject **decreased** from 79,382 to 64,728 (-18.46%).<br>• The percentage of Year 12 students enrolled in a technology subject **decreased** from 35.40% to 28.10% (-20.62%).<br>STEM Equity Monitor<br>• Year 12 enrolments in 02 Information technology **decreased** from 40,339 to 30,641 (-24.04%).<br>• Year 12 enrolments in 0101 Mathematical sciences **remained similar** from 191,131 to 187,777 (-1.75%). Note: there have been **decreases** for intermediate (-6.72%) and higher (-8.62%) mathematics. |
| **VET completions** 2019–2023 | • There were no data available on 0101 Mathematical sciences.<br>• VET completions in 0201 Computer science **decreased** from 3,055 to 215 (-92.96%).<br>• VET completions in 0203 Information systems **decreased** from 15,815 to 11,665 (-26.24%). |
| **VET enrolments** 2019–2023 | • There were no data available on 0101 Mathematical sciences.<br>• VET enrolments in 0201 Computer science **decreased** from 9,420 to 390 (-95.86%).<br>• VET enrolments in 0203 Information systems **increased** from 48,750 to 55,220 (13.27%). |
| **University graduates (all course levels and citizenship statuses)** 2013–2022 | • University graduates in 010103 Statistics **increased** from 290 to 1,227 (323.10%).<br>• University graduates in 020111 Data structures **increased** from 53 to 387 (630.19%). Note: there was a low of 32 graduates in 2015. From 2015 to 2022 there was a 1,109.38% **increase**.<br>• University graduates in 020303 Database management **increased** from 96 to 123 (28.13%). Note: there was a peak of 199 graduates in 2015. From 2015 to 2022 there was a 38.19% **decrease**. |
| **Undergraduate award course completions** 2014–2023 | • Undergraduate completions in 0101 Mathematical sciences **increased** from 367 to 691 for domestic students (88.28%) and **increased** 69 to 174 for international students (152.17%).<br>• Undergraduate completions in 0201 Computer science **increased** from 1,038 to 2,716 for domestic students (161.66%) and **increased** from 1,087 to 3,671 for international students (237.72%).<br>• Undergraduate completions in 0203 Information systems **remained similar** from 708 to 766 for domestic students (8.19%) and **increased** from 816 to 1,424 for international students (74.51%). |

| | |
|---|---|
| **Postgraduate award course completions** 2014–2023 | • Postgraduate completions in 0101 Mathematical sciences **increased** from 374 to 854 for domestic students (128.34%) and **increased** from 144 to 607 for international students (321.53%).<br>• Postgraduate completions in 0201 Computer science **increased** from 412 to 1,021 for domestic students (147.82%) and **increased** from 802 to 2,069 for international students (157.98%).<br>Note: There was a peak of 1,350 domestic students and of 2,558 international students in 2021. From 2021 to 2023 there was a 24.37% **decrease** in completions for domestic students, and a 19.12% **decrease** in international students.<br>• Postgraduate completions in 0203 Information systems **remained similar** from 511 to 533 for domestic students (4.31%) and **increased** from 1,394 to 2,487 for international students (78.41%).<br>Note: There was a peak of 4,171 for international students in 2020. From 2020 to 2023 there was a 40.37% **decrease** in international students. |
| **Undergraduate enrolments (commencing)** 2014–2023 | • Undergraduate enrolments in 0101 Mathematical sciences **increased** from 781 to 1,217 for domestic students (55.83%) and **increased** from 84 to 349 for international students (315.48%).<br>• Undergraduate enrolments in 0201 Computer science **increased** from 2,674 to 7,542 for domestic students (182.05%) and **increased** from 1,348 to 9,741 for international students (622.63%).<br>• Undergraduate enrolments in 0203 Information systems **decreased** from 1,935 to 1,373 for domestic students (-29.04%) and **increased** from 1,581 to 3,366 for international students (112.90%). |
| **Postgraduate enrolments (commencing)** 2014–2023 | • Postgraduate enrolments in 0101 Mathematical sciences **increased** from 531 to 928 for domestic students (74.76%) and **increased** from 237 to 1,294 for international students (445.99%).<br>Note: there was a peak of 1,364 domestic enrolments in 2021. From 2021 to 2023 there was a 31.96% **decrease**.<br>• Postgraduate enrolments in 0201 Computer science **increased** from 540 to 1,456 for domestic students (169.63%) and **increased** from 1,165 to 6,535 for international students (460.94%).<br>Note: Between 2020 and 2023 domestic enrolments **decreased** from 2,551 to 1,165 (-42.92%).<br>• Postgraduate enrolments in 0203 Information systems **decreased** from 800 to 625 for domestic students (-21.88%) and **increased** from 2,843 to 7,060 for international students (148.33%).<br>Note: There was a high of 1,218 domestic enrolments in 2020. From 2020 to 2023 there was a 48.69% **decrease**. There was a low of 2,680 international enrolments in 2021. From 2021 to 2023 there was a 163.43% **increase**. |

## WORKFORCE

**Current**
Various time periods

**Occupation shortages (2024)**

- The occupation of 224114 Data analyst had **shortages** in Western Australia and the Northern Territory.
- The occupation of 224115 Data scientist had **shortages** in Victoria and Western Australia.
- The occupation of 224116 Statistician had **shortages** in the Northern Territory.

**Research and teaching workforce (2019–2022)**

- The research and teaching workforce FTE in 01 Natural and physical sciences **decreased** from 3,651 to 3,433 (-5.97%).
- The research and teaching workforce headcount in 01 Natural and physical sciences **remained similar** from 3,897 to 3,923 (0.67%).
- The research and teaching workforce FTE in 02 Information technology **increased** from 1,089 to 1,302 (19.56%).
- The research and teaching workforce headcount in 02 Information technology **increased** from 1,162 to 1,353 (16.44%).

**Skilled temporary migration (2014–15 to 2023–2024)**

- Skilled temporary migration in 224113 Statistician **increased** from 26 to 48 (84.62%).

**Skilled permanent migration (2014–15 to 2023–2024)**

- Skilled permanent migration in 224113 Statistician **increased** from 49 to 94 (91.84%).

**Projected**
Various time periods

**Age structure analysis (2025–2035)**

- 0201 Computer science is projected to have an **expansive workforce**.
- 0203 Information systems is projected to have an **uncertain workforce**.
  Note: this uncertainty is due to extremely large prediction intervals due to low current workforce numbers but high graduate inflows.
- 0101 Mathematical sciences is projected to have an **expansive workforce**.

**Employment projections (2024–2034)**

- Employment of 2241 Actuaries, mathematicians and statisticians is projected to increase from 11,100 to 14,600 (31.4%). This is **higher than** total projected employment growth (13.7%).

## FUNDING

**R&D expenditure**
2012–2022

**Mathematical sciences**

- Expenditure on R&D in mathematical sciences by business **decreased** from $37 million* to $32 million** (-12.72%).
- Expenditure on R&D in mathematical sciences by government **increased** from $53 million* to $188 million (254.59%).
- Expenditure on R&D in mathematical sciences by higher education **decreased** from $211 million* to $177 million (-16.22%).
- Data on expenditure on R&D by private non-profit organisations not available for mathematical sciences

**Information and computing sciences**

- Expenditure on R&D in information and computing sciences by business **increased** from $6,903 million* to $7,927 million (14.83%).
- Expenditure on R&D in information and computing sciences by government **increased** from $319 million* to $442 million (38.87%).
- Expenditure on R&D in information and computing sciences by higher education **increased** from $416 million* to $631 million (51.69%).
- Expenditure on R&D in information and computing sciences by private non-profit organisations **increased** from $9 million* to $30 million (244.45%).
  *normalised to June 2022 Consumer Price Index.
  **ABS advises to use this value with caution.

## RESEARCH OUTPUT

**Publications 2015–2024**

**4905 Statistics**

- Australian research publications in 4905 Statistics **remained similar** from 471 to 441 (-6.37%).
- Australian research publications as a proportion of global publications in 4905 Statistics **decreased** 2.06% to 1.49% (-27.57%).
- The top three international collaborators in 4905 Statistics are the US, the UK and China.

**4605 Data management and data science**

- Australian research publications in 4605 Data management and data science **increased** from 1,612 to 2,689 (66.81%).
- Australian research publications as a proportion of global publications in 4605 Data management and data science **decreased** from 2.40% to 1.47% (-38.68%).
- The top three international collaborators in 4605 Data management and data science are China, the US and the UK.

**Patents 2015–2024**

- Australian patents in 4905 Statistics **decreased** from 8 to 5 (-37.50%).
  Note: not included in rating due to lower relevance. Patents in statistics are much lower that patents in data management and data science globally.
- Australian patents in 4605 Data management and data science **increased** from 337 to 602 (78.64%).

## Epidemiology

The data classification codes in scope are listed in the Epidemiology chapter.

| EDUCATION | |
|---|---|
| **Year 12 enrolments** 2013–2022 | ACARA<br>• Year 12 students studying science **remained similar** from 113,469 to 116,225 (2.43%).<br>• The percentage of Year 12 students enrolled in a science subject **remained similar** from 50.60% to 50.50% (-0.20%).<br>• Year 12 students enrolled in a mathematics subject **remained similar** from 162,367 to 156,253 (-3.77%).<br>• The percentage of Year 12 students enrolled in a mathematics subject **decreased** from 72.40% to 67.90% (-6.22%).<br>STEM Equity Monitor<br>• Year 12 enrolments in 0101 Mathematical sciences **remained similar** from 191,131 to 187,777 (-1.75%). Note: There have been **decreases** for intermediate (-6.72%) and higher (-8.62%) mathematics.<br>• Year 12 enrolments in 0109 Biological sciences **increased** from 56,522 to 61,491 (8.79%).<br>• Year 12 enrolments in 06 Health **increased** from 49,914 to 59,169 (18.54%). |
| **VET completions** 2019–2023 | • VET completions in 0613 Public health **decreased** from 15,630 to 13,965 (-10.65%). |
| **VET enrolments** 2019–2023 | • VET enrolments in 0613 Public health **remained similar** from 37,785 to 36,380 (-3.72%). |
| **University graduates (all course levels and citizenship statuses)** 2013–2022 | • University graduates in 061311 Epidemiology **increased** from 143 to 371 (159.44%). |
| **Undergraduate award course completions** 2014–2023 | • Undergraduate completions in 0613 Public health **decreased** from 1,603 to 1,418 for domestic students (-11.54%) and **decreased** from 228 to 154 for international students (-32.46%). |
| **Postgraduate award course completions** 2014–2023 | • Postgraduate completions in 0613 Public health **increased** from 2,469 to 3,810 for domestic students (54.31%) and **increased** from 590 to 953 for international students (61.53%). |

## EDUCATION

| | |
|---|---|
| **Undergraduate enrolments (commencing)** 2014–2023 | • Undergraduate enrolments in 0613 Public health **remained similar** from 3,555 to 3,528 for domestic students (-0.76%) and **increased** from 296 to 1,469 for international students (396.28%).<br>Note: there was a high of 5,526 domestic enrolments in 2017 and 5,257 in 2020. From 2020 to 2023 there was a 32.89% **decrease** in domestic enrolments. |
| **Postgraduate enrolments (commencing)** 2014–2023 | • Postgraduate enrolments in 0613 Public health **increased** from 3,678 to 4,836 for domestic students (31.48%) and **increased** from 856 to 4,035 for international students (371.38%).<br>Note: there was a high of 5,713 domestic and a low of 1,151 international enrolments in 2021. From 2021 to 2023 there was a 15.35% **decrease** in domestic enrolments and a 250.57% **increase** in international enrolments. |

## WORKFORCE

| | |
|---|---|
| **Current** Various time periods | Occupation shortages (2024)<br>• The occupation of 253399 Specialist physicians not elsewhere classified (nec) had national shortages.<br>Note: 253399 Specialist physicians nec includes public health physicians. However, this also includes occupations outside the scope of epidemiology, such as clinical pharmacologists and sleep medicine physicians.<br>Research and teaching workforce (2019–2022)<br>• The research and teaching workforce FTE in 06 Health **remained similar** from 4,181 to 4,150 (-0.74%).<br>• The research and teaching workforce headcount in 06 Health **remained similar** from 5,273 to 5,114 (-3.02%).<br>Skilled temporary migration (2014–15 to 2023–2024)<br>• Skilled temporary migration in 253399 Specialist physician NEC **increased** from 9 to 24 (166.67%).<br>Skilled permanent migration (2014–15 to 2023–2024)<br>• Skilled permanent migration in 253399 Specialist physician NEC **increased** from <5 to 7. |
| **Projected** Various time periods | Age structure analysis (2025-2035)<br>• No age structure analysis was performed for 0613 Public health.<br>Employment projections (2024-2034)<br>• No direct ANZSCO match.<br>• Employment of 2533 Specialist physicians is projected to **increase** from 15,300 to 19,900 (29.9%). This is **higher than** total projected employment growth (13.7%). |

## FUNDING

| | |
|---|---|
| **R&D expenditure** 2012–2022 | • Expenditure on R&D in biomedical, clinical and health sciences by business **increased** from $1,182 million* to $3,200 million (170.71%).<br>• Expenditure on R&D in biomedical, clinical and health sciences by government **remained similar** from $708 million* to $743 million (4.85%).<br>• Expenditure on R&D in biomedical, clinical and health sciences by higher education **increased** from $3,545 million* to $4,763 million (34.35%).<br>• Expenditure on R&D in biomedical, clinical and health sciences by private non-profit organisations **increased** from $941 million* to $1,367 million (45.27%).<br>*normalised to June 2022 Consumer Price Index. |

## RESEARCH OUTPUT

| | |
|---|---|
| **Publications** 2015–2024 | **4202 Epidemiology**<br>• Australian research publications in 4202 Epidemiology **increased** from 804 to 1,046 (30.10%).<br>• Australian research publications as a proportion of global publications in 4202 Epidemiology **decreased** from 4.66% to 4.13% (-11.53%).<br>• The top three international collaborators in 4202 Epidemiology are the US, the UK and China. |
| **Patents** 2015–2024 | • There were 11 or fewer Australian patents in 4202 Epidemiology each year, with an annual average of 4.4 Australian patents. |

## Geoscience

The data classification codes in scope are listed in the Geoscience chapter.

### EDUCATION

**Year 12 enrolments 2013–2022**

ACARA

- Year 12 students studying science **remained similar**, slightly increasing from 113,469 to 116,225 (2.43%).
- The percentage of Year 12 students enrolled in a science subject **remained similar** from 50.60% to 50.50% (-0.20%).
- Year 12 students enrolled in a mathematics subject **remained similar** from 162,367 to 156,253 (-3.77%).
- The percentage of Year 12 students enrolled in a mathematics subject **decreased** from 72.40% to 67.90% (-6.22%).

STEM Equity Monitor

- Year 12 enrolments in 0101 Mathematical sciences **remained similar** from 191,131 to 187,777 (-1.75%). Note: there have been **decreases** for intermediate (-6.72%) and higher (-8.62%) mathematics.
- Year 12 enrolments in 0103 Physics and astronomy have **decreased** from 30,686 to 25,984 (-15.32%)
- Year 12 enrolments in 0105 Chemical sciences **decreased** from 38,993 to 36,516 (-6.35%).
- Year 12 enrolments in 0107 Earth sciences **increased** from 3,109 to 4,444 (43%). Note: 0107 Earth sciences had the lowest number of Year 12 enrolments compared to other science fields in 2022.
- Year 12 enrolments in 03 Engineering and related technologies **remained similar** from 16,951 to 17,212 (1.54%).

**VET completions 2019–2023**

- There was no data available on 0107 Earth sciences.
- VET completions in 0311 Geomatic engineering **remained similar** from 645 to 605 (-6.20%). Note: completions were lower between these years, with the lowest at 495 in 2022.

**VET enrolments 2019–2023**

- VET enrolments in 0107 Earth sciences **decreased** from 5 to 0 (-100%). Note: there were no students recorded between 2021 and 2023.
- VET enrolments in 0311 Geomatic engineering **remained similar** from 1,385 to 1,360 (-1.81%). Note: enrolments were lower between these years, with the lowest at 1,160 in 2021.

**University graduates (all course levels and citizenship statuses) 2013–2022**

- University graduates in 010703 Geology **decreased** from 528 to 305 (-42.23%).
- University graduates in 010705 Geophysics **decreased** from 48 to 14 (-70.83%).
- University graduates in 010707 Geochemistry **remained similar**, with no change from 8 to 8 (0%).
- University graduates in 010711 Hydrology **decreased** from 56 to 35 (-37.50%).
- University graduates in 031100 Geomatic engineering not further defined **increased** from 30 to 83 (176.67%).
- University graduates in 031101 Surveying **increased** from 154 to 233 (51.30%).
- University graduates in 031102 Mapping science **decreased** from 26 to 16 (-38.46%).
- University graduates in 031103 Geomatic engineering not elsewhere classified **decreased** from 59 to 40 (-32.20%).

| | |
|---|---|
| **Undergraduate award course completions** 2014–2023 | • Undergraduate completions in 0107 Earth sciences **decreased** from 264 to 103 for domestic students (-60.98%) and **decreased** from 35 to 19 for international students (-45.71%).<br>• Undergraduate completions in 0311 Geomatic engineering **increased** from 129 to 175 for domestic students (35.66%) and **decreased** from 13 to 11 for overseas students (-15.38%).<br>Note: there was a peak at 226 in 2022 for domestic students. |
| **Postgraduate award course completions** 2014–2023 | • Postgraduate completions in 0107 Earth sciences **decreased** from 264 to 197 for domestic students (-25.38%) and **remained similar** from 132 to 131 for international students (-0.76%).<br>• Postgraduate completions in 0311 Geomatic engineering **increased** from 68 to 99 for domestic students (45.59%) and increased from 32 to 54 for overseas students (68.75%).<br>Note: there was a sharp **decrease** between 2015 and 2018 from 101 to 38 for domestic students before increasing again. |
| **Undergraduate enrolments (commencing)** 2014–2023 | • Undergraduate enrolments in 0107 Earth sciences **decreased** from 358 to 234 for domestic students (-34.64%) and **decreased** from 75 to 26 for international students (-65.33%).<br>Note: there was a low of 105 domestic enrolments in 2017. From 2017 to 2023 there was a 122.86% increase.<br>• Undergraduate enrolments in 0311 Geomatic engineering **increased** from 350 to 400 for domestic students (14.29%) and **increased** from 15 to 28 for overseas students (86.67%). |
| **Postgraduate enrolments (commencing)** 2014–2023 | • Postgraduate enrolments in 0107 Earth sciences **decreased** from 355 to 299 for domestic students (-15.77%) and **increased** from 193 to 238 for international students (23.32%).<br>Note: there was a low of 95 international enrolments in 2021. From 2021 to 2023 there was a 150.53% increase.<br>• Postgraduate enrolments in 0311 Geomatic engineering **increased** from 109 to 144 for domestic students (32.11%) and **increased** from 40 to 101 for overseas students (152.50%). |

## WORKFORCE

**Current**
Various time periods

Occupation shortages (2024)

- The occupation 2344 Geologists, geophysicists and hydrogeologists had national **shortages** due to a suitability gap.
  Note: Jobs and Skills Australia defines a suitability gap as 'those occupations where there are enough qualified applicants, but they are not regarded as suitable.'
- The occupation of 234411 Geologist had national **shortages**.
- The occupation of 234412 Geophysicist had national **shortages**.
- The occupation of 234413 Hydrogeologist had national **shortages**.
- The occupation 2322 Surveyors and spatial scientists had national **shortages** due to a long training gap.
  Note: Jobs and Skills Australia defines a long training gap shortage as 'there being few qualified applicants per vacancy and a long training pathway – corresponding to a Certificate III or above.'
- The occupation of 232212 Surveyor had national **shortages**.
- The occupation of 232213 Cartographer had a **shortage** in Western Australia.
- The occupation of 232214 Other spatial scientist had a **shortage** in Western Australia.

Research and teaching workforce (2019–2022)

- The research and teaching workforce FTE in 01 Natural and physical sciences **decreased** from 3,651 to 3,433 (-5.97%).
- The research and teaching workforce headcount in 01 Natural and physical sciences **remained similar** from 3,897 to 3,923 (0.67%).
- The research and teaching workforce FTE in 03 Engineering and related technologies **increased** from 1,945 to 2,128 (9.41%).
- The research and teaching workforce headcount in 03 Engineering and related technologies **increased** from 2,006 to 2,275 (13.41%).

Skilled temporary migration (2014–15 to 2023–2024)

- Skilled temporary migration in 234411 Geologist **increased** from 129 to 185 (43.41%).
- Skilled temporary migration in 234412 Geophysicist **decreased** from 73 to 9 (-87.67%).
- Skilled temporary migration in 234413 Hydrogeologist **increased** from <5 to 28.
- Skilled temporary migration in 232212 Surveyor **increased** from 37 to 149 (302.70%).
- Skilled temporary migration in 232213 Cartographer was low, with <5 per year.
- Skilled temporary migration in 232214 Other spatial scientist **increased** from 6 to 24 (300%).

Skilled permanent migration (2014–15 to 2023–2024)

- Skilled permanent migration in 234411 Geologist **decreased** from 247 to 51 (-79.35%).
- Skilled permanent migration in 234412 Geophysicist **decreased** from 42 to 16 (-61.90%).
- Skilled permanent migration in 234413 Hydrogeologist was low, less than 12 a year.
- Skilled permanent migration in 232212 Surveyor **decreased** from 85 to 68 (-20.00%).
- Skilled permanent migration in 232213 Cartographer **decreased** from 8 to <5.
- Skilled permanent migration in 232214 Other spatial scientist **increased** from 39 to 50 (28.21%).

**Projected**
Various time periods

Age structure analysis (2025–2035)

- 0107 Earth sciences is projected to have an **ageing workforce**.
- 0311 Geomatic engineering is projected to have an **ageing workforce**.

Employment projections (2024–2034)

- Employment of 2344 Geologists, geophysicists, and hydrogeologists is projected to **increase** from 11,800 to 13,400 (13.7%). This is **similar to** total projected employment growth (13.7%).
- Employment of 2322 Surveyors and spatial scientists is projected to **increase** 17,000 to 20,100 (17.8%). This is **similar to** total projected employment growth (13.7%).

## FUNDING

**R&D expenditure 2012–2022**

- Expenditure on R&D in Earth sciences by business **remained similar** from $154 million* to $151 million (-2.05%).
- Expenditure on R&D in Earth sciences by government **remained similar** from $298 million* to $283 million (-4.94%).
- Expenditure on R&D in Earth sciences by higher education **remained similar** from $362 million* to $350 million (-3.40%).
- Data not available for private non-profit organisations.

*normalised to June 2022 Consumer Price Index.

Note: Engineering has not been included for assessment of R&D expenditure as Earth sciences is the most directly relevant at the two-digit level.

## RESEARCH OUTPUT

**Publications 2015–2024**

3703 Geochemistry

- Australian research publications in 3703 Geochemistry **remained similar** from 800 to 804 (0.50%).
- Australian research publications as a proportion of global publications in 3703 Geochemistry **decreased** from 7.97% to 5.38% (-32.43%).
- The top three international collaborators in 3703 Geochemistry are China, the US and the UK.

3704 Geoinformatics

- Australian research publications in 3704 Geoinformatics **increased** from 118 to 262 (122.03%).
- Australian research publications as a proportion of global publications in 3704 Geoinformatics **decreased** from 1.09% to 0.85% (-22.28%).
- The top three international collaborators in 3704 Geoinformatics are China, the US and Iran.

3705 Geology

- Australian research publications in 3705 Geology **decreased** from 2,108 to 1,838 (-12.81%).
- Australian research publications as a proportion of global publications in 3705 Geology **decreased** from 5.42% to 3.27% (-39.71%).
- The top three international collaborators in 3705 Geology are China, the US, the UK.

3706 Geophysics

- Australian research publications in 3706 Geophysics **decreased** from 953 to 811 (-14.90%).
- Australian research publications as a proportion of global publications in 3706 Geophysics **decreased** from 6.89% to 4.05% (-41.12%).
- The top three international collaborators in 3706 Geophysics are China, the US, and the UK.

3707 Hydrology

- Australian research publications in 3707 Hydrology **remained similar** from 500 to 479 (-4.20%).
- Australian research publications as a proportion of global publications in 3707 Hydrology **decreased** from 4.84% to 2.51% (-48.19%).
- The top three international collaborators in 3707 Hydrology are China, the US and the UK.

3709 Physical geography and environmental geoscience

- Australian research publications in 3709 Physical geography and environmental geoscience **increased** from 643 to 764 (18.82%).
- Australian research publications as a proportion of global publications in 3709 Physical geography and environmental geoscience **decreased** from 4.01% to 3.04% (-24.18%).
- The top three international collaborators in 3709 Physical geography and environmental geoscience are the US, China and the UK.

4013 Geomatic engineering

- Australian research publications in 4013 Geomatic engineering **increased** from 281 to 426 (51.60%).
- Australian research publications as a proportion of global publications in 4013 Geomatic engineering **decreased** from 2.75% to 1.72% (-37.50%).
- The top three international collaborators in 4013 Geomatic engineering are China, the US and the Netherlands.

**Patents 2015–2024**

- Australian patents in 3703 Geochemistry **increased** from 29 to 33 (13.79%).
- Australian patents in 3704 Geoinformatics **remained similar** from 49 to 48 (-2.04%).
- Australian patents in 3705 Geology **remained similar** from 1032 to 1022 (-0.97%).
- Australian patents in 3706 Geophysics **increased** from 15 to 22 (46.67%).
- Australian patents in 3707 Hydrology **increased** from 29 to 44 (51.72%).
- Australian patents in 3709 Physical geography and environmental geoscience **decreased** from 17 to 6 (-64.71%).
- Australian patents in 4013 Geomatic engineering **increased** from 19 to 42 (121.05%).

## Materials science

The data classification codes in scope are listed in the Materials science chapter.

| EDUCATION | |
|---|---|
| **Year 12 enrolments** 2013–2022 | ACARA<br>• Year 12 students enrolled in a science **remained similar** from 113,469 to 116,225 (2.43%).<br>• The percentage of Year 12 students enrolled in a science subject **remained similar** from 50.60% to 50.50% (-0.20%).<br>• Year 12 students enrolled in a mathematics subject **remained similar** from 162,367 to 156,253 (-3.77%).<br>• The percentage of Year 12 students enrolled in a mathematics subject **decreased** from 72.40% to 67.90% (-6.22%).<br>STEM Equity Monitor<br>• Year 12 enrolments in 0101 Mathematical sciences **remained similar** from 191,131 to 187,777 (-1.75%). Note: there have been decreases for intermediate (-6.72%) and higher (-8.62%) mathematics.<br>• Year 12 enrolments in 0103 Physics and astronomy **decreased** from 30,686 to 25,984 (-15.32%)<br>• Year 12 enrolments in 0105 Chemical sciences **decreased** from 38,993 to 36,516 (-6.35%).<br>• Year 12 enrolments in 0109 Biological sciences **increased** from 56,522 to 61,491 (8.79%).<br>• Year 12 enrolments in 03 Engineering and related technologies **remained similar** from 16,951 to 17,212 (1.54%). |
| **VET completions** 2019–2023 | • There were no VET completions data available for 0103 Physics and astronomy.<br>• VET completions in 0105 Chemical sciences have **increased** from 30 to 85 (183.33%). Note: VET completions were at 95 in 2020 and 2021, and rose to 100 in 2022. There was a 15% decrease between 2022 and 2023.<br>• VET completions in 0303 Process and resources engineering have **decreased** from 16,510 to 13,525 (-18.08%). |
| **VET enrolments** 2019–2023 | • There were no VET enrolments data available for 0103 Physics and astronomy.<br>• VET enrolments in 0105 Chemical sciences have **increased** from 280 to 495 (76.79%).<br>• VET enrolments in 0303 Process and resources engineering have **decreased** from 54,640 to 46,700 (-14.53%). |
| **University graduates (all course levels and citizenship statuses)** 2013–2022 | • University graduates in 030301 Chemical engineering **increased** from 899 to 989 (10.01%). Note: University graduates in 030301 Chemical engineering peaked at 1,401 in 2018. There was a 29.41% decrease from 2018 to 2022.<br>• University graduates in 030305 Materials engineering **increased** from 206 to 308 (49.51%).<br>• University graduates in 010500 Chemical sciences not further defined **increased** from 573 to 831 (45.03%). Note: There was a peak at 1,015 in 2021.<br>• University graduates in 010501 Organic chemistry **increased** from 35 to 311 (788.57%).<br>• University graduates in 010503 Inorganic chemistry **increased** from 13 to 34 (161.54%). Note: Low numbers and year to year fluctuations. There were peaks at 39 in 2015 and 2018, and lows at 11 in 2014 and 2019.<br>• University graduates in 010599 Chemical sciences not elsewhere classified **decreased** from 479 to 417 (-12.94%).<br>• University graduates in 010301 Physics **increased** from 517 to 661 (27.85%). Note: There was a peak in 2020 at 737 and in 2021 at 729. |

## EDUCATION

| | |
|---|---|
| **Undergraduate award course completions** 2014–2023 | • Undergraduate completions in 0103 Physics and astronomy **remained similar** from 77 to 72 for domestic students (-17.65%) and **remained similar** from <5 to <5 for international students.<br>• Undergraduate completions in 0105 Chemical sciences **decreased** from 174 to 83 for domestic students (-52.30%) and **decreased** from 17 to 9 for international students (47.06%).<br>• Undergraduate completions in 0303 Process and resources engineering **decreased** from 621 to 178 for domestic students (-71.34%) and **decreased** from 378 to 95 for international students (-74.87%). |
| **Postgraduate award course completions** 2014–2023 | • Postgraduate completions in 0103 Physics and astronomy **remained similar** from 198 to 217 for domestic students (9.60%) and **increased** from 107 to 149 for international students (39.25%).<br>• Postgraduate completions in 0105 Chemical sciences **increased** from 150 to 201 for domestic students (34.00%) and **increased** from 136 to 203 for international students (49.26%).<br>• Postgraduate completions in 0303 Process and resources engineering **decreased** from 470 to 360 for domestic students (-23.40%) and **increased** from 520 to 692 for international students (33.08%). |
| **Undergraduate enrolments (commencing)** 2014–2023 | • Undergraduate enrolments in 0103 Physics and astronomy **remained similar** from 126 to 122 for domestic students (-3.17%) and **increased** from 10 to 25 for international students (150.00%).<br>• Undergraduate enrolments in 0105 Chemical sciences **increased** from 153 to 207 for domestic students (35.29%) and **decreased** from 19 to 5 for international students (-73.68%).<br>• Undergraduate enrolments in 0303 Process and resources engineering **decreased** from 961 to 298 for domestic students (-68.99%) and **decreased** from 429 to 110 for international students (-74.36%). |
| **Postgraduate enrolments (commencing)** 2014–2023 | • Postgraduate enrolments in 0103 Physics and astronomy **remained similar** from 206 to 216 for domestic students (4.85%) and **increased** from 160 to 216 for international students (35.00%).<br>• Postgraduate enrolments in 0105 Chemical sciences **decreased** from 214 to 152 for domestic students (-28.97%) and **increased** from 212 to 394 for international students (85.85%).<br>Note: there was a low of 150 international enrolments in 2021. From 2021 to 2023 there was a 162.67% increase.<br>• Postgraduate enrolments in 0303 Process and resources engineering **decreased** from 659 to 416 for domestic students (-36.87%) and **increased** from 724 to 970 for international students (33.98%). |

## WORKFORCE

| | |
|---|---|
| **Current**<br>Various time periods | **Occupation shortages (2024)**<br>• The occupation 233111 Chemical engineer had national **shortages**.<br>• The occupation 233112 Materials engineer had national **shortages**.<br>• The occupation 234211 Chemist had no **shortages**.<br>**Research and teaching workforce (2019–2022)**<br>• The research and teaching workforce FTE in 01 Natural and physical sciences **decreased** from 3,651 to 3,433 (-5.97%).<br>• The research and teaching workforce headcount in 01 Natural and physical sciences **remained similar** from 3,897 to 3,923 (0.67%).<br>• The research and teaching workforce FTE in 03 Engineering and related technologies **increased** from 1,945 to 2,128 (9.41%).<br>• The research and teaching workforce headcount in 03 Engineering and related technologies **increased** from 2,006 to 2,275 (13.41%).<br>**Skilled temporary migration (2014–15 to 2023–2024)**<br>• Skilled temporary migration in 233111 Chemical engineer **increased** from 60 to 67 (11.67%).<br>• Note: There was a low at 18 in 2016-17.<br>• Skilled temporary migration in 233112 Materials engineer **remained similar** from 12 to 12 (0%).<br>• Skilled temporary migration for the occupation 234211 Chemist **increased** from 23 to 37 (60.87%).<br>**Skilled permanent migration (2014–15 to 2023–2024)**<br>• Skilled permanent migration in 233111 Chemical engineer **decreased** from 337 to 286 (-15.13%).<br>• Skilled permanent migration in 233112 Materials engineer **decreased** from 69 to 47 (-31.88%).<br>• Skilled permanent migration for the occupation 234211 Chemist **decreased** from 169 to 77 (-54.44%). |
| **Projected**<br>Various time periods | **Age structure analysis (2025–2035)**<br>• 0303 Process and resources engineering is projected to have a **declining workforce**.<br>• 0105 Chemical sciences is projected to have a stationary **workforce**.<br>• 0103 Physics and astronomy is projected to have an ageing **workforce**.<br>**Employment projections (2024–2034)**<br>• Employment of 2342 Chemists, and food and wine scientists is projected to **increase** from 10,300 to 11,600 (13.3%). This is **similar to** total projected employment growth (13.7%).<br>• Employment of 2331 Chemical and materials engineers is projected to **increase** from 6,700 to 8,100 (20.4%). This is **higher than** total projected employment growth (13.7%). |

## FUNDING

**R&D expenditure**
2012–2022

### Chemical sciences

- Expenditure on R&D in chemical sciences by business **decreased** from $535 million* to $393 million (-26.54%).
- Expenditure on R&D in chemical sciences by government **decreased** from $204 million* to $181 million (-10.90%).
- Expenditure on R&D in chemical sciences by higher education **decreased** from $449 million* to $352 million (-21.67%).
- Data not available for private non-profit organisations.

### Physical sciences

- Expenditure on R&D in physical sciences by business **increased** from $59 million* to $138 million** (136.50%).
- Expenditure on R&D in physical sciences by government **increased** from $160 million* to $282 million (75.81%).
- Expenditure on R&D in physical sciences by higher education **increased** from $392 million to $441 million (12.59%).
- Data not available for private non-profit organisations.

### Engineering

- Expenditure on R&D in engineering by business **decreased** from $10,910 million* to $5, 400 million (-50.51%).
- Expenditure on R&D in engineering by government **decreased** from $679 million* to $485 million (-28.65%).
- Expenditure on R&D in engineering by higher education **increased** from $1,199 million to $1,650 (37.60%).
- Expenditure on R&D in engineering by private non-profit organisations **remained similar** from $15 million* to $14 million (-4.74%).

*normalised to June 2022 Consumer Price Index.

** ABS notes that this figure is unreliable for general use (standard error greater than 50%).

## RESEARCH OUTPUT

| | |
|---|---|
| **Publications** 2015–2024 | **3403 Macromolecular and materials chemistry**<br>• Australian research publications in 3403 Macromolecular and materials chemistry **increased** from 952 to 1,469 (54.31%).<br>• Australian research publications as a proportion of global publications in 3403 Macromolecular and materials chemistry **decreased** from 2.00% to 1.70% (-15.15%).<br>• The top three international collaborators in 3403 Macromolecular and materials chemistry are China, the US the UK.<br>**4003 Biomedical engineering**<br>• Australian research publications in 4003 Biomedical engineering **increased** from 803 to 1,152 (43.46%).<br>• Australian research publications as a proportion of global publications in 4003 Biomedical engineering **decreased** from 2.40% to 1.98% (-17.59%).<br>• The top three international collaborators in 4003 Biomedical engineering are China, the US and the UK.<br>**4016 Materials engineering**<br>• Australian research publications in 4016 Materials engineering **increased** from 2,183 to 3,736 (71.14%).<br>• Australian research publications as a proportion of global publications in 4016 Materials engineering decreased from 2.17% to 1.95% (-10.24%).<br>• The top three international collaborators in 4016 Materials engineering are China, the US and the UK.<br>**4004 Chemical engineering**<br>• Australian research publications in 4004 Chemical engineering **increased** from 1,295 to 1,669 (28.88%).<br>• Australian research publications as a proportion of global publications in 4004 Chemical engineering **decreased** from 2.95% to 1.88% (-36.22%).<br>• The top three international collaborators in 4004 Chemical engineering are China, the US and India.<br>**4014 Manufacturing engineering**<br>• Australian research publications in 4014 Manufacturing engineering **increased** from 399 to 696 (74.44%).<br>• Australian research publications as a proportion of global publications in 4014 Manufacturing Engineering **decreased** from 1.28% to 1.10% (-14.37%).<br>• The top three international collaborators in 4014 Manufacturing engineering are China, the US and the UK.<br>**4018 Nanotechnology**<br>• Australian research publications in 4018 Nanotechnology **remained similar** from 805 to 774 (-3.85%). Note: there was a peak at 1,045 in 2021.<br>• Australian research publications as a proportion of global publications in 4018 Nanotechnology **decreased** from 1.91% to 1.65% (-13.78%).<br>• The top three international collaborators in 4018 Nanotechnology are China, the US and India.<br>**5104 Condensed matter physics**<br>• Australian research publications in 5104 Condensed matter physics **decreased** from 504 to 433 (-14.09%).<br>• Australian research publications as a proportion of global publications in 5104 Condensed matter physics **decreased** from 1.32% to 1.04% (-21.35%).<br>• The top three international collaborators in 4018 Nanotechnology are China, the US and Germany. |
| **Patents** 2015-2024 | • Australian patents in 3403 Macromolecular and materials chemistry **increased** from 408 to 466 (14.22%).<br>• Australian patents in 4016 Materials engineering **increased** from 380 to 570 (50.00%).<br>• Australian patents in 4004 Chemical engineering **decreased** from 273 to 230 (-15.75%).<br>• Australian patents in 4014 Manufacturing engineering **decreased** from 579 to 475 (-17.96%).<br>• Australian patents in 4018 Nanotechnology **increased** from 35 to 67 (91.43%).<br>• Australian patents in 4003 Biomedical engineering **increased** from 351 to 410 (16.81%).<br>• Australian patents in 5104 Condensed matter physics **increased** from 31 to 118 (280.65%). |

# REFERENCES


1. Edelman. *Edelman Trust Barometer. Trust and the crisis of grievance* https://www.edelman.com/trust/2025/trust-barometer (2025).

2. Hartcher, P. Is this Gentle Jim's JFK moment? If it is, he's overlooked one thing. *The Sydney Morning Herald* (2025).

3. Australian Government. *Intergenerational Report 2023: Australia's Future to 2063.* https://treasury.gov.au/publication/2023-intergenerational-report (2023).

4. Chalmers, J. Address to the National Press Club, Canberra: Economic reform in our second term. https://ministers.treasury.gov.au/ministers/jim-chalmers-2022/speeches/address-national-press-club-canberra-5 (2025).

5. Sagan, *C. Cosmos.* (Random House Inc, 1980).

6. McNutt, M. & Crow, M. M. "Universities Are the Invisible Hand." *Issues Sci Technol* **41**, 36–39 (2025).

7. Museum of Australian Democracy at Old Parliament House. Bob Hawke. *Election Speeches* https://electionspeeches.moadoph.gov.au/speeches/1990-bob-hawke (1990).

8. Chubb, I. Speech to launch "The Dawkins Period." https://www.chiefscientist.gov.au/2013/10/speech-to-launch-the-dawkins-period (2013).

9. Turnbull, M. Launch of the National Innovation and Science Agenda. https://www.malcolmturnbull.com.au/media/launch-of-the-national-innovation-and-science-agenda1 (2015).

10. A moment of truth for America. https://homes.cs.washington.edu/~lazowska/cra/ceo.letter.html (1995).

11. OECD. PISA: Programme for International Student Assessment. https://www.oecd.org/en/about/programmes/pisa.html.

12. Marchant, T. & Kennedy, S. Year 12 mathematics participation report card. (2024).

13. Australian Mathematical Sciences Institute. Year 12 mathematics participation report card. https://amsi.org.au/?publications=year-12-mathematics-participation-report-card-numbers-remain-at-record-lows-and-female-participation-declines (2025).

14. Australian Teacher Workforce Data. National trends teacher workforce. https://www.aitsl.edu.au/research/australian-teacher-workforce-data/atwd-reports/national-trends-teacher-workforce-jun2025 (2025).

15. NCVER (National Centre for Vocational Education Research). DataBuilder. https://www.ncver.edu.au/research-and-statistics/data/databuilder (2025).

16. Australian Government Department of Education. Key findings from the 2023 higher education student statistics. https://www.education.gov.au/higher-education-statistics/student-data/selected-higher-education-statistics-2023-student-data/key-findings-2023-student-data (2025).

17. Universities Australia. Research workforce. https://universitiesaustralia.edu.au/policy-submissions/research-innovations/research-workforce/.

18. Australian Government Department of Education. Research training program. https://www.education.gov.au/research-block-grants/research-training-program (2025).

19. Fair Work Ombudsman. Minimum wages increase 3.5% from 1 July 2025. https://www.fairwork.gov.au/about-us/workplace-laws/annual-wage-review/annual-wage-review-2024-2025 (2025).

20. Universities Australia. Australia must join global race to settle international students. https://universitiesaustralia.edu.au/media-item/australia-must-join-global-race-to-settle-international-students/ (2022).

21. Clarivate. Highly cited researchers - 2024 analysis. https://clarivate.com/highly-cited-researchers/analysis/ (2025).

22. Australian Government Department of Industry Science and Resources. *Strategic Examination of R&D Discussion Paper.* https://storage.googleapis.com/converlens-au-industry/industry/p/prj31a02fa37c9ece8370e29/page/SERD_Discussion_Paper.pdf (2025).

23. Australian Academy of Science. *Issues Paper: Incentivising Business Investment in R&D.* https://www.science.org.au/supporting-science/science-advice-and-policy/reports-and-publications/issues-paper-incentivising-business-investment-in-rd (2025).

24. Australian Academy of Science. *Submission—2025–26 Pre-Budget Submission.* https://www.science.org.au/supporting-science/science-advice-and-policy/submissions-to-government/submission-2025-26-pre-budget-submission (2025).

25. Australia's Chief Scientist. *2020 Australia's STEM Workforce Report*. https://www.chiefscientist.gov.au/news-and-media/2020-australias-stem-workforce-report (2020).

26. Department of Industry Science and Resources. The state of STEM gender equity in 2023. https://www.industry.gov.au/news/state-stem-gender-equity-2023 (2023).

27. Australian Food and Grocery Council. *Food and Grocery Export Growth Strategy 2023.* https://afgc.org.au/wp-content/uploads/2024/10/Food-and-Grocery-Export-Growth-Strategy-2023-Final.pdf (2023).

28. Collins, J. & Chisholm, A. Joint media release: Aussie agriculture celebrated on the world stage. https://minister.agriculture.gov.au/collins/media-releases/aussie-agriculture-celebrated-world-stage (2024).

29. Australian Bureau of Statistics. 99% of farm businesses in Australia are Australian owned. https://www.abs.gov.au/AUSSTATS/abs@.nsf/0F98DB4640388725FCA257905007C152A (2017).

30. Bilotto, F. et al. Costs of transitioning the livestock sector to net-zero emissions under future climates. *Nature Communications 2025* 16:1 16, 1–19 (2025).

31. Hajkowicz, S. A. *et al. Artificial Intelligence: Solving Problems, Growing the Economy and Improving Our Quality of Life*. https://www.csiro.au/en/research/technology-space/ai/artificial-intelligence-roadmap (2019).

32. CSIRO CarbonLock. Accelerating discovery of novel CO2 capture materials using AI and machine learning. https://research.csiro.au/carbonlock/accelerating-discovery-of-novel-co2/ (2023).

33. Cranney, K. Magpie geese return with help from ethical AI and Indigenous Knowledge. *CSIRO News* https://www.csiro.au/en/news/all/articles/2019/november/magpie-geese-return-ethical-ai-indigenous-knowledge (2019).

34. The Reef 2050 Traditional Owner Steering Group. *Reef 2050 Traditional Owner Implementation Plan.* https://reefto.au/resources/#2022 (2022).

35. Australian Academy of Science. Reef Futures Roundtables Report. https://www.science.org.au/supporting-science/science-advice-and-policy/reports-and-publications/reef-futures-roundtables-report (2023).

36. Harris, K.-L., Jensz, F. & Baldwin, G. Who's Teaching Science? Meeting the Demand for Qualified Science Teachers in Australian Secondary Schools. https://www.acds.edu.au/wp-content/uploads/teachsci.pdf (2005).

37. AI will transform science — now researchers must tame it. *Nature* 621, 658 (2023).

38. Van Noorden, R. & Perkel, J. M. AI and science: what 1,600 researchers think. *Nature* **621**, 672–675 (2023).

39. Hajkowicz, S. et al. *Artificial Intelligence for Science: Adoption Trends and Future Development Pathways*. https://www.csiro.au/en/research/technology-space/ai/artificial-intelligence-for-science-report (2022).

10. Weis, J. W. & Jacobson, J. M. Learning on knowledge graph dynamics provides an early warning of impactful research. *Nature Biotechnology 2021 39:10* **39**, 1300–1307 (2021).

41. Prillaman, M. Is ChatGPT making scientists hyper-productive? The highs and lows of using AI. *Nature* **627**, 16–17 (2024).

42. Commission, P. *Interim Report - Harnessing Data and Digital Technology*. www.pc.gov.au/inquiries/current/data-digital (2025).

43. ACARA (Australian Curriculum, A. and R. A. Year 12 subject enrolments. https://www.acara.edu.au/reporting/national-report-on-schooling-in-australia/year-12-subject-enrolments (2025).

44. Department of Industry Science and Resources. Year 12 subject enrolment in STEM and other fields. *STEM Equity Monitor* https://www.industry.gov.au/publications/stem-equity-monitor/primary-and-secondary-school-data/year-12-subject-enrolment-stem-and-other-fields (2024).

45. Jobs and Skills Australia. Occupation shortage list. https://www.jobsandskills.gov.au/data/occupation-shortages-analysis/occupation-shortage-list (2024).

46. Department of Home Affairs. BP0014 Temporary work (skilled) visas granted report at 2025-06-30. https://data.gov.au/data/dataset/visa-temporary-work-skilled/resource/13e0c12d-f17a-40f6-ba9f-fedcdfaf5b8c (2025).

47. Department of Home Affairs. BP0068L Permanent migration program (skilled & family) outcomes snapshot – annual statistics 2014-15 to 2023-24 v100.xlsx. https://data.gov.au/data/dataset/permanent-migration-program-skilled-family/resource/4e9559a4-a37f-414b-a716-24abff9d8e9a (2025).

48. Nguyen, K. V. & Hyndman, R. *The Future Age Structure of Scientific Disciplines - Report for Australian Academy of Science* (Unpublished). (2025).

49. Jobs and Skills Australia. Employment projections. https://www.jobsandskills.gov.au/data/employment-projections (2025).

50. Department of Industry Science and Resources. Teaching and research workforce in STEM and other fields. *STEM Equity Monitor* https://www.industry.gov.au/publications/stem-equity-monitor/workforce-data/teaching-and-research-workforce-stem-and-other-fields (2024).

51. Australian Bureau of Statistics. Research and experimental development, government and private non-profit organisations, Australia. https://www.abs.gov.au/statistics/industry/technology-and-innovation/research-and-experimental-development-government-and-private-non-profit-organisations-australia (2024).

52. Australian Bureau of Statistics. Research and experimental development, higher education organisations, Australia. https://www.abs.gov.au/statistics/industry/technology-and-innovation/research-and-experimental-development-higher-education-organisations-australia (2024).

53. Australian Bureau of Statistics. Research and experimental development, businesses, Australia. https://www.abs.gov.au/statistics/industry/technology-and-innovation/research-and-experimental-development-businesses-australia (2023).

54. Tech Council of Australia. *Meeting the AI Skills Boom.* https://techcouncil.com.au/wp-content/uploads/Meeting-the-AI-Skills-Boom-2024.v2.pdf (2024).

55. Australian Academy of Science. *Australian Climate Science Capability Review.* https://www.science.org.au/supporting-science/science-policy-and-analysis/reports-and-publications/australian-climate-science-capability-review (2017).

Australian Academy of Science